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RED DEER RIVER FLOW REGULATION PROPOSAL FISHERIES STUDY

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BIOLOGICAL CONSULTANTS



December 12, 1974

Mr. A.T. McPhail, P. Eng.
Project Co-ordinator
Planning Division
Department of the Environment
Room 601, J.J. Bowlen Building
620 Seventh Avenue S.W.
CALGARY, Alberta

Dear Mr. McPhail:

We are pleased to submit the report entitled

Red Deer River Flow Regulation Proposal, Fisheries Study.

This report was prepared by P. McCart and M. Jones of Aquatic Environments Limited. If you have any questions regarding this report, please contact us.

Yours,

AQUATIC ENVIRONMENTS LIMITED

Peter McCart

Peter McCart, President

CG

Encl.

SYNOPSIS

Fisheries investigations were carried out on the Red Deer River to determine the existing fish resources of the area. Particular emphasis was placed on the distribution, status and utilization of populations of cold and warm water game species and on how the construction of a flow regulation dam might affect these populations.

These are the general conclusions of the study:

1. Stream habitats within the Red Deer River Drainage can be divided into two broad categories, warm water and cold water. On the Red Deer River itself, the division between the two types is in the vicinity of the two damsites.

2. The cold water fish fauna inhabits the cooler, less productive, faster flowing waters and is dominated by the mountain whitefish and several species of suckers. Aside from the mountain whitefish, cold water sports species include the brown trout, brook trout, and rarely, the Dolly Varden and rainbow trout.

3. The warm water fish fauna inhabits warmer, more

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productive, more turbid, slower moving waters. The warm water fauna is dominated by various species of suckers and small forage fishes. The most important warm water sports species are the goldeye, walleye, northern pike and to a lesser extent the mooneye and sauger. The distribution of the mountain whitefish overlaps that of the warm water species to a point downstream of the City of Red Deer. While the mountain whitefish is considered to be cold water species in terms of its spawning requirements, with most spawning taking place above the damsites in cold water habitat, a considerable portion of the population feeds and overwinters below the damsites in warm water habitat.

No precise prediction of the effects of the dam construction on fish populations is possible because of the complex interrelationship of the fish species with each other and their environment. However, the following major changes in fish populations could occur:

1. Upstream

- a) Unless effective fish passage facilities are provided, either dam will block the upstream migration of large numbers of mountain whitefish, the most abundant cold water sports species in the study area. This could result in some reduction of the total mountain whitefish population above the damsites.

- b) The upstream migrations of goldeye and mooneye, important warm water sports species, would also be blocked.

2. In the impoundment

- a) It is likely that both reservoirs will follow a pattern of overall increase in fish population immediately after impoundment followed by a decline.
- b) Coarse fish, particularly the white sucker, are likely to dominate populations in the reservoir.
- c) The mountain whitefish will probably continue to be the most abundant sports species.
- d) Of the trout and char species, the brown trout is likely to do best.
- e) Of the other trout and char, the rainbow trout is likely to do better than brook trout, Dolly Varden or cutthroat.
- f) Of the warm water sports species, the pike is most likely to persist in the reservoirs.

3. Downstream

- a) It is likely that stabilization of streamflow with increased winter flows and increased winter oxygen levels will improve conditions for warm water sports fish populations throughout the Red Deer River downstream of the dam.
- b) Decreased silt loads downstream may favour mooneye over goldeye.
- c) Walleye may benefit if the tailrace of the dam provides additional spawning area.
- d) Mountain whitefish populations are likely to decline downstream of the dam.

From a fisheries viewpoint, it appears that the net effect of construction of either of the proposed dams will be beneficial, trading off a segment of the mountain whitefish population in return for improved winter conditions throughout the Red Deer River downstream of the dam. In terms of changes to fish habitat within the main stem of the Red Deer River, flow regulation will:

1. Cause no change to the approximately 100 miles of the Red Deer River upstream of the damsites.

2. Cause major changes, largely detrimental, within the approximately 6 mile stream segment inundated by the reservoir itself.
3. Create improved conditions, particularly in the winter as the result of increased flows and higher oxygen levels, throughout the approximately 300 miles of the Red Deer River downstream of the damsites.

The lower site, site 6 is preferred over the Raven River site, site 7, as benefits are maximized and potential detrimental effects are minimized.

The following recommendations are made concerning the construction and operation of the dam.

During the construction phase:

- a) Care should be taken to minimize long-term soil erosion and sediment production within the project area.
- b) Proper storage and disposal of potential pollutants, *e.g.*, fuels, lubricants, cement, salt, sewage, etc, should be required.

- c) If permanent fish passage facilities are going to be provided, then care should be taken to ensure that passage is provided during construction.
- d) Water velocities in diversion works should not exceed 5 fps for distances greater than 60 feet.
- e) The final closure of the dam should be timed, if possible, for the period from August 15 to October 1.
- f) Care should be taken to avoid heavy mortalities to fish resulting from the use of explosives.

During the operational phase:

- a) Initially the reservoir should be operated during the summer as a natural lake with epilimnial release only.
- b) Winter discharges should be maintained at least at historical monthly averages, but should not exceed the minimum volumes necessary to provide adequate supplies of high quality water downstream.
- c) Changes in discharge volumes should be gradual.

- d) Consideration should be given to the provision of fish passage facilities.
- e) Consideration should be given to the provision of fish culture facilities.
- f) To take advantage of the initial high productivity of the reservoir, it is recommended that rainbow trout be stocked.

Further studies are recommended if a decision is made to actually construct a dam at one of the two sites. These include:

- a) Migration Study, to obtain quantitative data concerning the actual numbers and patterns of fish moving past the damsites.
- b) Fish Passage Facilities, to design an adequate fishway for the fish species involved.
- c) Monitoring Studies, to monitor selected physical, chemical, and biological parameters to obtain baseline data.
- d) Management Studies, to provide data for the rational management of the fisheries in the reservoir and downstream.

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INTRODUCTION

Aquatic Environments Limited was contracted by the Planning Division, Alberta Department of the Environment in April 1974 to conduct fisheries investigations on the Red Deer River in order to assess the impact of a proposed flow regulation dam upon the fish resources of the area.

Briefly, the purposes of the study were to:

- 1) determine the existing fish resources of the area, particularly the distribution, status and utilization of populations of cold and warm water game species,
- 2) determine how the construction of a dam and reservoir on the Red Deer River might affect these populations,
- 3) suggest measures or alternate solutions which would alleviate the potential detrimental effects of the proposed development,
- 4) outline the benefits, if any, of the proposed flow regulation project.

DESCRIPTION OF THE STUDY AREA

The Study Area (Figures 1 and 2) extends from near the Banff National Park boundary downstream approximately 250 miles to Drumheller. It includes the lower reaches of a number of tributary streams as well as the Raven River. The latter was examined in considerable detail because it would be extensively flooded by the reservoir behind the uppermost of the two alternate damsites (Sites 6 and 7) under active consideration. It is felt that the Study Area is adequate to properly assess the impact of proposed flow regulation throughout the Red Deer River drainage.

The damsites are approximately midway in the Study Area. For convenience, the Study Area has been divided into two Regions (Figure 1). The upper segment, upstream of the damsites, has been designated Region I and the lower segment, downstream of the damsites, Region II.

The Red Deer River originates in permanent snow fields in the Rocky Mountains at Banff National Park about 150 miles west of the city of Red Deer, Alberta. It flows in a generally west-east direction, across Alberta from the mountains through the foothills to the prairies before joining the South Saskatchewan River in the vicinity of Empress,

Figure 1. Map of the Study Area.

NORTHWEST TERRITORIES

ALBERTA

RED DEER RIVER FLOW REGULATION PROPOSAL FISHERIES INVESTIGATIONS

BRITISH COLUMBIA

SASKATCHEWAN

STUDY AREA —

DAM SITES 

■ GRANDE PRAIRIE

■ EDMONTON

REGION II

REGION I

RED DEER

SUNDRE

■ DRUMHELLER

■ CALGARY

ROCKY MOUNTAINS



MONTANA

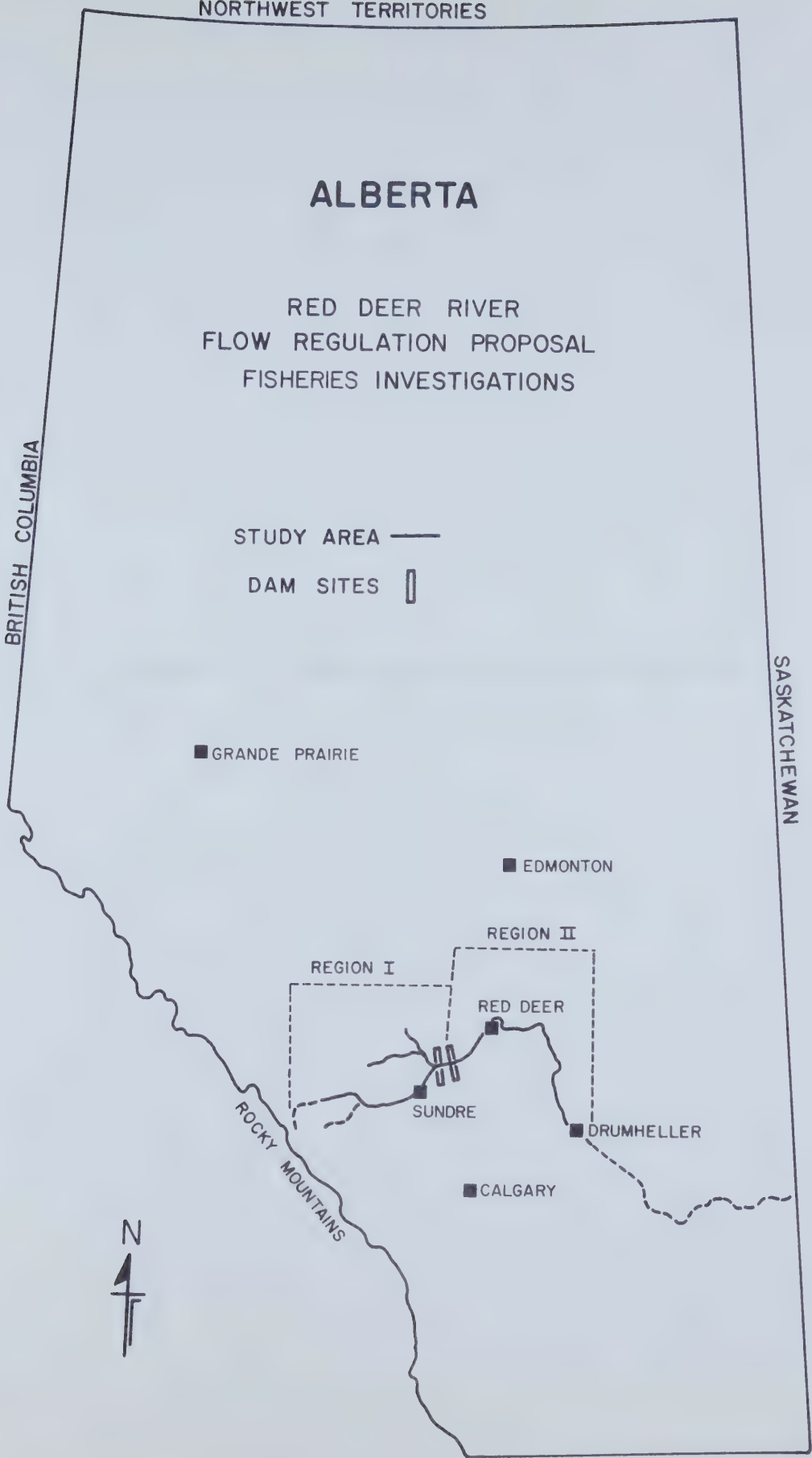
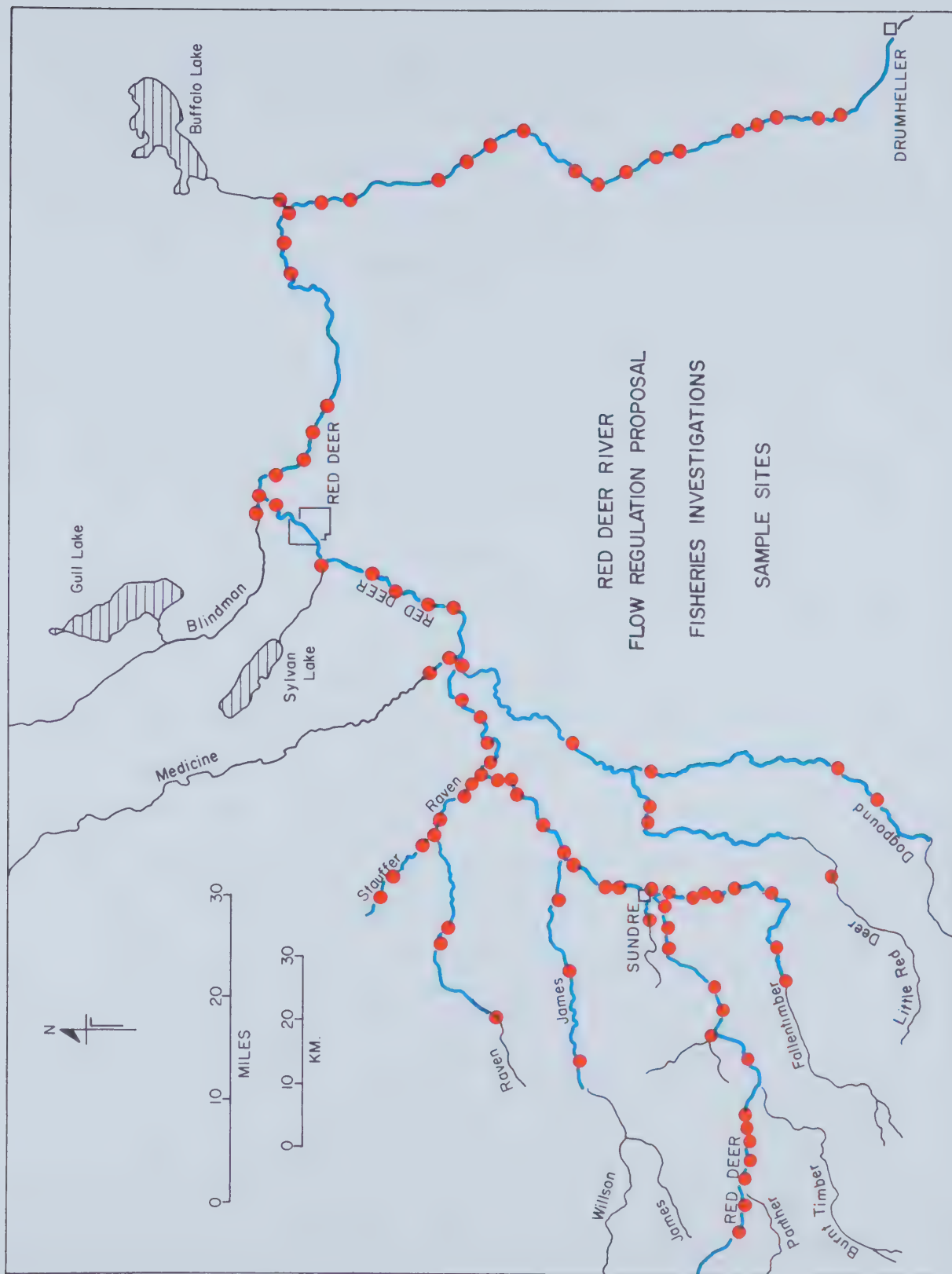


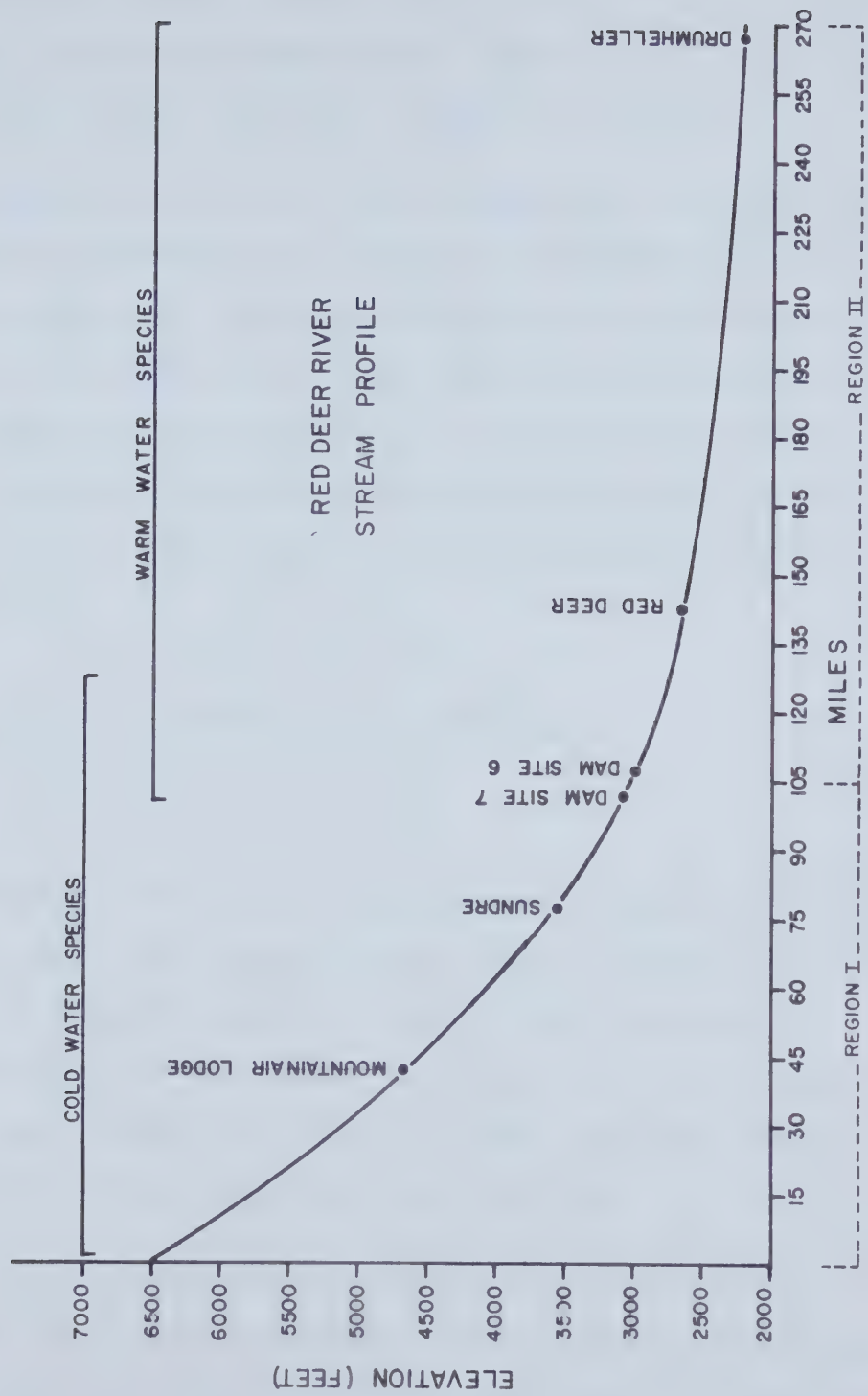
Figure 2. Map showing the sample locations within the Study Area.



Saskatchewan. The elevation of the river ranges from approximately 6000 feet in its headwaters to 2200 feet near Drumheller. In the upper portion of the Study Area, Region I, the river is relatively steep (Figure 3) dropping an average of 32 feet per mile. Within this stream segment there are extensive areas of multi-channel, braided stream from just above Sundre to the mouth of the Raven River. These gravelly areas are subject to considerable channel shifting and alternation during freshets. Downstream of Site 6, in Region II, the river gradient is much reduced, averaging only 8 feet per mile downstream to Drumheller. The stream is generally single-channeled and is deeper and slower than it is upstream.

Summer water flows are maintained by snow melt, groundwater and precipitation. There is little lake drainage and winter base flows are maintained largely by groundwater. Within the Study Area, precipitation ranges from about 21 inches per annum in the west to about 14 inches per annum in the east. The frost-free period ranges between 60 and 100 days with some 80 inches of snow occurring in the mountains to the west compared with an average of only 40 inches in the prairie portion to the east (Physical Environment Inventory of the Red Deer Regional Planning Commission Area, 1972-1973). Tributary streams range from the clear, cold, fast flowing waters of sub-alpine valleys in the Rocky Mountains, to that of slow, warm, coffee-coloured prairie streams near Drumheller.

Figure 3. Stream profile showing the
gradient of the Red Deer
River within the Study Area.



Because of higher elevation, the greater proportion of runoff deriving directly from snowmelt and the high current velocities, spring and summer water temperatures in Region I are generally lower than those in Region II (Table 1).

The portion of the Red Deer drainage that is within the Study Area is strategically centered, equidistant from the two major population centres of Edmonton and Calgary and is bisected by the major north-south transportation corridor. This accessibility and proximity to large resident and tourist populations plus the inherent attractiveness of the Red Deer River drainage give it great potential for human use.

MATERIALS AND METHODS

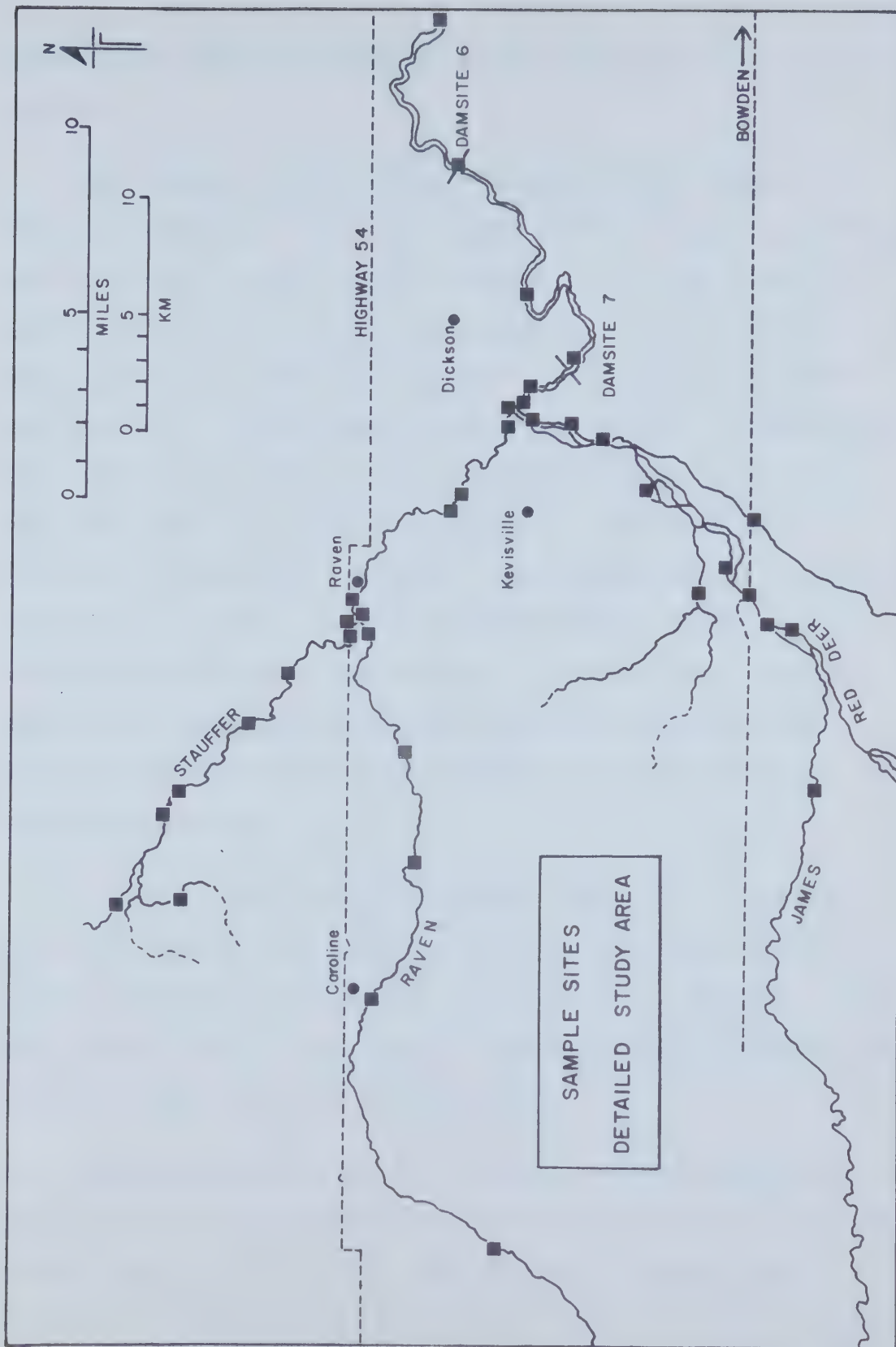
Fisheries surveys were conducted at 59 sample sites on the main stem of the Red Deer River and at 41 sites on tributaries (Figures 2 and 4). Many of the sites were reached by road but an 18-foot riverboat with a 50 hp jet unit was used extensively on the Red Deer and Raven Rivers to reach areas where road access was limited.

Fish were captured by a variety of means including a Smith-Root Type V A electrofisher, monofilament gillnets of various meshes, seines and, to a limited extent, by angling. The

Table 1. Water temperature levels in Regions I and II, mainstem Red Deer River, during three two-month periods in 1974. Summary of data in Appendix A.

APRIL - MAY Average	MAY Range	JUNE - JULY Average	JULY Range	AUGUST - SEPTEMBER Average	SEPTEMBER Range
<u>Region I</u>					
8.4°C	3-12°C	14.3°C	9-18.5°C	13.4°C	11-17°C
(47.1°F)	(37-54°F)	(57.7°F)	(48-65°F)	(56.1°F)	(52-63°F)
<u>Region II</u>					
10.4°C	8-13°C	18°C	17-19°C	17°C	15-19°C
(50.7°F)	(46-55°F)	(64°F)	(63-66°F)	(63°F)	(59-66°F)

Figure 4. Detailed map showing the sample sites in the Raven River and vicinity.



methods employed were dictated by the type of habitat being sampled.

The methods of life history analysis were similar to those described by McCart and Craig (1973). Sample specimens were dissected in the field or packed in ice and frozen for later dissection. Fish were measured to the nearest one millimeter fork length and weighed to 0.1 gram on a triple beam balance. Gonads were examined and weighed to determine sex and state of maturity and otoliths and/or scales were taken for age and growth determination. Otoliths were preserved in glycerin for later examination under a binocular microscope. Scales were cleaned and mounted between glass slides for projection and reading. Copies of the original data sheets have been forwarded to Dr. Martin Paetz and Mr. Mel Kraft of the Fish and Wildlife Division, Alberta Lands and Forests.

A wetsuit and snorkle equipment were used on several occasions during fall spawning and overwintering surveys to locate concentrations of fish or verify their absence. This was the only way to effectively sample potential spawning and overwintering locations in deep water.

During the course of field studies regular measurements were made of water temperature (pocket thermometer), dissolved oxygen (Hach OX-10, oxygen kit), specific conductivity (Beckman RA-2A Portable Conductivity Meter) and pH (Seibold

Portable pH Meter). These data are summarized in Appendix A.

FISH POPULATIONS IN THE STUDY AREA

Thirty-three species of fish have been reported from the Study Area. Table 2 includes a list of these species with approved common and scientific names, a four letter code based on the common name and an indication of their relative abundance. They have been grouped as either cold water (Group 1), warm water (Group 2) sports species, or as other, non-sports species.

Maps have been prepared to illustrate the distributions within the study area of the numerically most important species. An additional map has been prepared presenting capture localities for eight minor non-game species. The maps are based on data collected during the course of this study (Appendix B), data from literature records, principally those in Henderson and Peter (1969) and Paetz and Nelson (1970), and unpublished data transmitted on a personal communication basis by M. Kraft, Regional Fisheries Biologist, Alberta Lands and Forests, Fish and Wildlife Division, Red Deer, Alberta.

The distribution maps for the commoner species indicate:

Table 2. Fish species reported from the Red Deer River study area. Data from Paetz and Nelson (1970) and Henderson and Peter (1969). Asterisks indicate those species captured during the course of this study. Relative abundance of species within the study area is also indicated: A, abundant; C, common; R, rare.

<u>COMMON NAME</u>	<u>CODE</u>	<u>SCIENTIFIC NAME</u>	<u>RELATIVE ABUNDANCE</u>
Cold Water Sports Species			
Trouts and Chars (Family Salmonidae)			
*Dolly Varden	DOLL	<i>Salvelinus malma</i>	R
*Brook trout	BKTR	<i>Salvelinus fontinalis</i>	C
*Brown trout	BNTR	<i>Salmo trutta</i>	C
Cutthroat trout		<i>Salmo clarki</i>	R
*Rainbow trout	RBTR	<i>Salmo gairdneri</i>	R
Whitefishes (Family Coregonidae)			
*Mountain whitefish	MTWF	<i>Prosopium williamsoni</i>	A
Warm Water Sports Species			
Pikes (Family Esocidae)			
*Northern pike	PIKE	<i>Esox lucius</i>	C
Mooneyes (Family Hiodontidae)			
*Mooneye	MOON	<i>Hiodon tergisus</i>	C
*Goldeye	GOLD	<i>Hiodon alosoides</i>	A
Perches (Family Percidae)			
Yellow perch		<i>Perca flavescens</i>	R
*Sauger	SAUG	<i>Stizostedion canadense</i>	C
*Walleye	WALL	<i>Stizostedion vitreum</i>	C

Table 2 (continued).

<u>COMMON NAME</u>	<u>CODE</u>	<u>SCIENTIFIC NAME</u>	<u>RELATIVE ABUNDANCE</u>
Other Non-Sports Species			
Cods (Family Gadidae)			
Burbot	BURB	<i>Lota lota</i>	C
Minnows (Family Cyprinidae)			
*Longnose dace	LNDC	<i>Rhinichthys cataractae</i>	A
Flathead chub		<i>Platygobio gracilis</i>	R
*Lake chub	LKCB	<i>Couesius plumbeus</i>	A
*Pearl dace	PLDC	<i>Semotilus margarita</i>	R
Northern redbelly dace		<i>Chrosomus eos</i>	R
*Finescale dace	FNDC	<i>Chrosomus neogaeus</i>	R
Fathead minnow		<i>Pimephales promelas</i>	R
Emerald shiner		<i>Notropis atherinoides</i>	R
*River shiner	RVSH	<i>Notropis blennius</i>	R
Spottail shiner		<i>Notropis hudsonius</i>	R
Suckers (Family Catostomidae)			
Quillback		<i>Carpoides cyprinus</i>	R
*Shorthead redhorse	SRSK	<i>Moxostoma macrolepidotum</i>	C
*Longnose sucker	LNSK	<i>Catostomus catostomus</i>	A
*White sucker	WTSK	<i>Catostomus commersoni</i>	A
*Mountain sucker	MTSK	<i>Catostomus platyrhynchus</i>	C
Trout Perches (Family Percopsidae)			
*Trout perch	TRPH	<i>Percopsis omiscomaycus</i>	A
Sticklebacks (Family Gasterosteidae)			
*Brook stickleback	BRST	<i>Culaea inconstans</i>	C
Sculpins (Family Cottidae)			
*Slimy sculpin	SLSC	<i>Cottus cognatus</i>	C
*Spoonhead sculpin	SPSC	<i>Cottus ricei</i>	R
Perches (Family Percidae)			
Iowa darter		<i>Etheostoma exile</i>	R

1) The range, in red, in which the species is known to occur. It should be emphasized that this is presently recorded distribution of the species and that it is likely that unrecorded specimens have been and will be taken outside the indicated range;

2) Waterbodies, in blue, in which collections were made during the course of this study but where the species were not captured;

3) Waterbodies, in black, which are part of the Red Deer drainage but were not sampled either because relevant information was already available, or because there would be little or no impact upon these waterbodies from the project;

4) Locations, indicated by red dots, outside the area of the present study but within the Red Deer drainage, where the species has been reported.

Cold Water Sports Species (Group 1)

This section includes a brief description of the life histories of those cold water sports species which sustain a sports fishery within the Study Area. These are the Dolly Varden, the brook trout, the brown trout and the mountain whitefish. Some consideration is given to other trout species.

Dolly Varden

The Dolly Varden, sometimes referred to as the bull trout, is a char native to the Red Deer River drainage. Only four individuals were taken during the course of this study, three in the vicinity of Sundre and one near the mouth of the Raven River. This was less than 1% of the total number of cold water sports fishes captured (Table 3). It appears to be virtually absent from the Raven River, rare but widely distributed in the Red Deer River upstream of Damsite 7 and locally common in some headwater tributaries, *e.g.*, the Panther River where it is frequently taken by anglers. It is likely that the Dolly Varden was more abundant and widely distributed in the Red Deer River drainage prior to the introduction of two exotic species, the brown trout and brook trout. Nelson (1965) describes a comparable situation in the Kananaskis River, Alberta and ascribes a marked reduction in the distribution and numbers of Dolly Varden in large part to displacement by brown trout. The Dolly Varden, once common throughout the Kananaskis drainage, is now rare and restricted to a few locations, including the lower Kananaskis Reservoir and a few headwater tributaries.

The species is relatively slow growing and late maturing as well as being behaviourally vulnerable to angling (Nelson, 1965). These circumstances have also undoubtedly contributed to the species' decline in many areas. Of the four specimens taken during the course of this study only one was mature,

Table 3 . Species composition and totals for fish captured during fisheries investigations, Red Deer River Flow Regulation Proposal Study, 1974.

Species	REGION I		REGION II		REGION I & II	
	N	% total for area	N	% total for area	N	% total both areas
COLD WATER SPORTS SPECIES						
Mountain whitefish	436	19	30	0.4	466	4.6
Brown trout	19	0.8	-	0	19	0.2
Brook trout	53	2.3	-	0	53	0.5
Dolly Varden	4	0.1	-	0	4	0.04
Rainbow trout	2	0.09	-	0	2	0.02
Subtotal	514	22.3	30	0.4	544	5.4
WARM WATER SPORTS SPECIES						
Northern pike	13	0.6	4	0.05	17	0.1
Mooneye	12	0.5	10	0.13	22	0.2
Goldeye	26	1.1	11	0.14	37	0.4
Walleye	28	1.2	2	0.03	30	0.3
Sauger	-	0	1	0.01	1	0.01
Subtotal	79	3.4	28	0.36	107	1.0
NON-GAME SPECIES						
Burbot	2	0.09	2	0.03	4	0.04
Longnose dace	970	42	3600	46	4570	45
Lake chub	23	1.0	530	6.8	553	5.5
Longnose sucker	167	7.2	57	0.7	224	2.2
White sucker	232	10	2010	26	2242	22.2
Mountain sucker	201	8.7	7	0.09	208	2.0
Shorthead redhorse	1	0.04	204	2.6	205	2.0
Troutperch	71	3.0	1310	17	1381	13.7
Pearl dace	1	0.04	-	0	1	0.01
Finescale dace	2	0.09	-	0	2	0.02
River shiner	2	0.09	12	0.1	14	0.1

(continued)

Table 3. Continued

Species	REGION I		REGION II		REGION I & II	
	N	% total for area	N	% total for area	N	% total both areas
NON-GAME SPECIES (cont'd)						
Brook stickleback	15	0.6	2	0.3	17	0.2
Slimy sculpin	2	0.09	4	0.5	6	0.06
Spoonhead sculpin	14	0.6	-	0	14	0.1
Subtotal	1703	74.3	7738	99.2	9441	93.5
Grand total	2296		7796		10092	

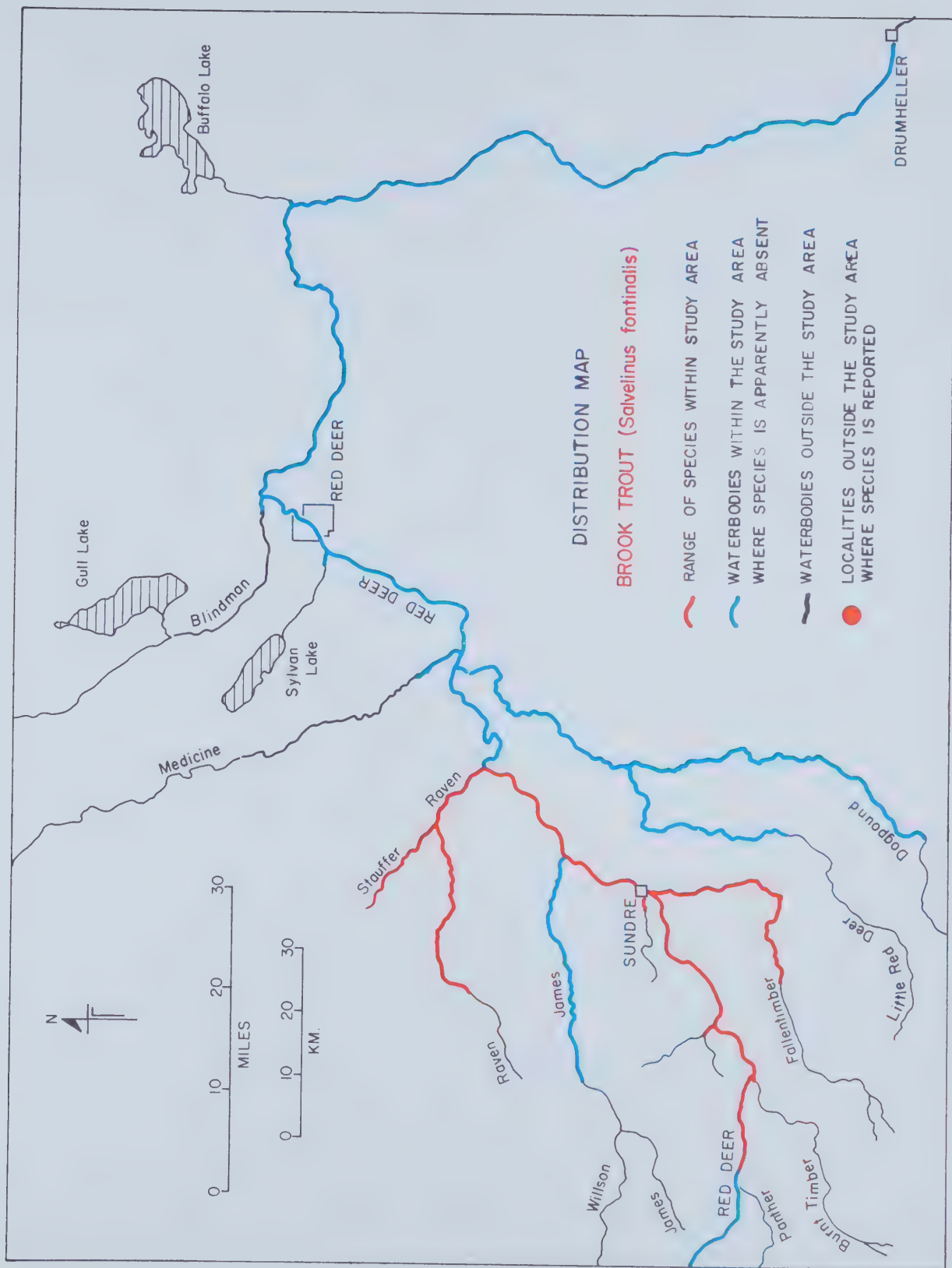
a 463 mm female aged 7 years. The others were immature males, the largest being 241 mm and aged at 4 years.

Brook Trout

The brook trout is a char which has been widely introduced in Alberta. It has been present in the Red Deer River drainage for at least 35 years. The present distribution of the species within the study area is indicated in Figure 5. It occurs in relatively low densities throughout the mainstem of the Red Deer River from Damsite 7 upstream to at least the mouth of the Panther River. It reaches its greatest abundance in tributary streams, particularly the upper reaches of Stauffer Creek where densities of 1310 fish per mile have been reported (Shirvell, 1972). It is also common in the lower reaches of Stauffer Creek, throughout the Raven River and in Fallentimber and Burnt Timber Creeks. In many tributary streams (*e.g.*, Stauffer, Raven and Fallentimber) the brook trout is most abundant in the headwater reaches and is replaced by brown trout downstream where flows are slower and warmer. In Stauffer Creek, for example, Shirvell (1972) reports that,

"Electrofishing section one (summer maximums of 50-52F) supported predominantly brook trout, electrofishing section two (summer maximums 52-66F) equal numbers of brook and brown trout, while electrofishing section three (summer maximums 66-70F) supported predominantly brown trout."

Figure 5. Distribution of the brook trout within the Study Area.



The length-frequency distribution of brook trout captured during this study is given in Figure 6. The maximum length of fish in the sample did not exceed 300 mm, considerably less than the 500+ mm lengths attained by brown trout. Shirvell (1972) found a comparable difference between brook and brown trout taken in Stauffer Creek.

Ages for brook trout were determined from otoliths. The resultant growth data are given in Table 4 and presented diagrammatically in Figure 7. The data are for a combined sample (N=22) of fish from Stauffer Creek (N=9), Sundre Creek (N=3), Fallentimber Creek (N=1) and the Red Deer River itself (N=9). The maximum ages attained (age 4) exceed by one year those indicated by Shirvell (1972) for brook trout from Stauffer Creek. In addition, the growth rates are somewhat slower than those Shirvell reports. There are several possible reasons for this:

- 1) The scale and otolith methods may differ in their accuracy. Among slow growing populations, otoliths are generally deemed to be more accurate in estimating age, especially among the older, larger fish. In these circumstances, the scale method tends to underestimate actual ages resulting in underestimates of maximum ages attained by the population and overestimates of growth rates. This problem can only be resolved if detailed comparisons are made of scale and otolith ages determined from known-age fish.

Figure 6. Comparison of the length-frequency of brook trout and brown trout captured during the study.

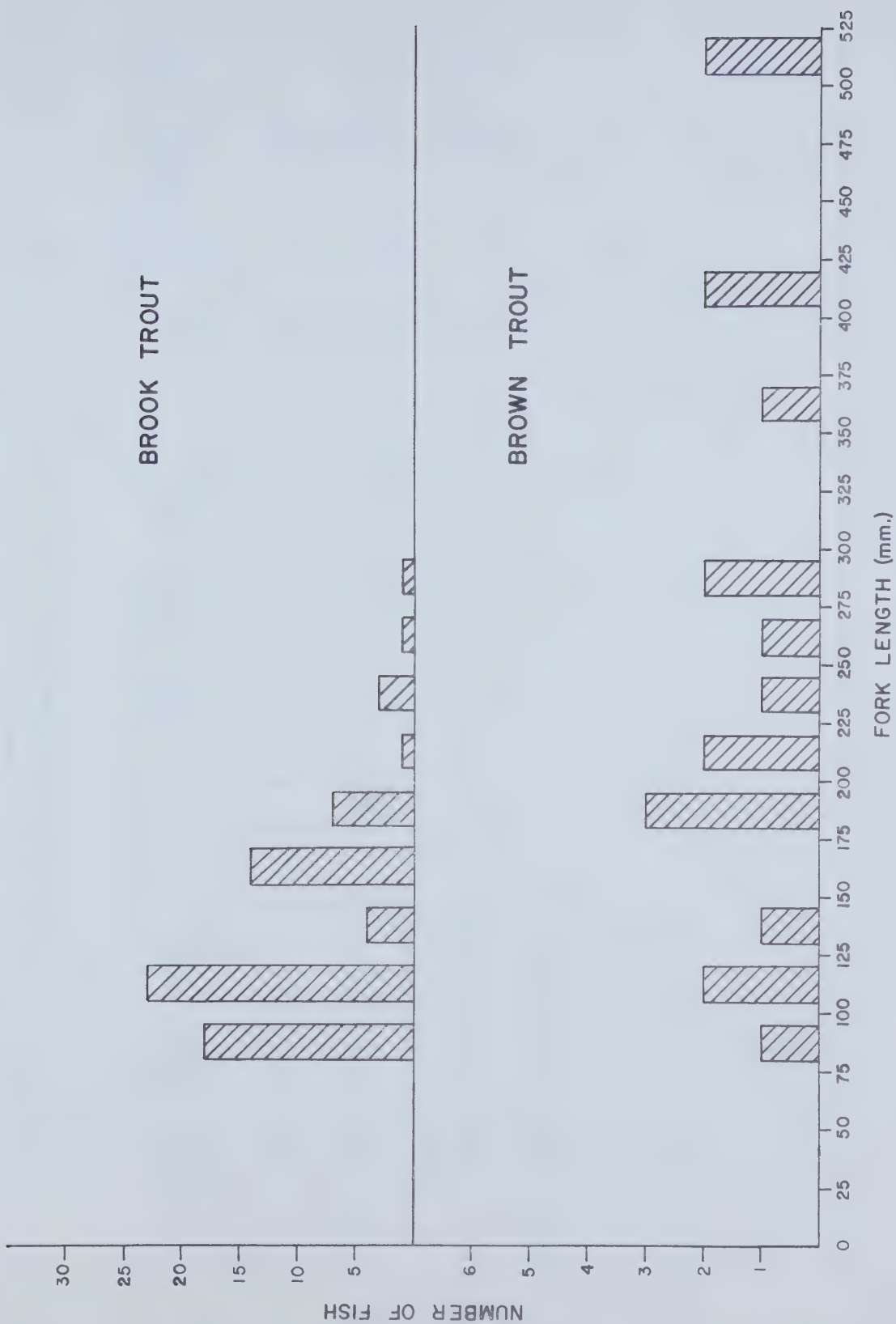
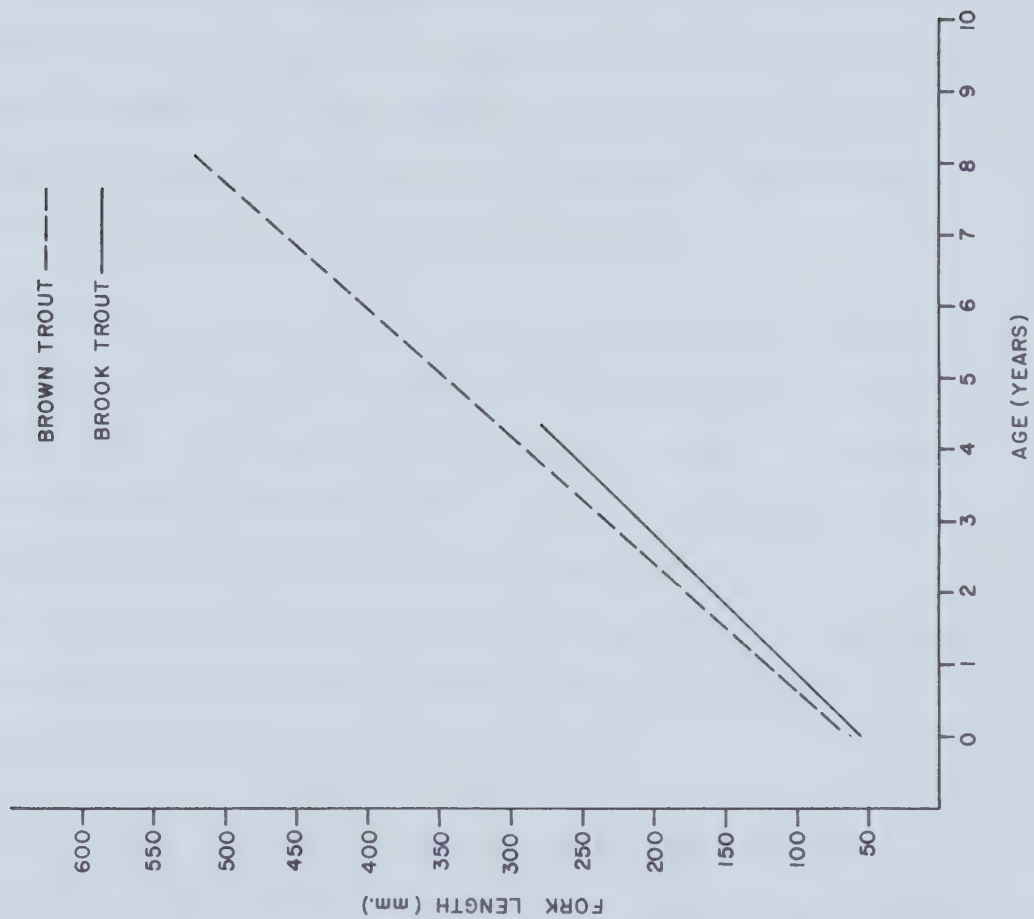


Table 4. Otolith age-fork length relationships of three coldwater sports species. Samples taken during studies of the proposed Red Deer River Damsites, 1974. S.D. is standard deviation.

Age	BROWN TROUT			BROOK TROUT			MOUNTAIN WHITEFISH			
	N	Fork Length Mean S.D.	Range (mm)	N	Fork Length Mean S.D.	Range (mm)	N	Fork Length Mean S.D.	Range (mm)	
1	1	120	-	8	102	15.6	40	78	11.4	50-101
2				5	163	8.9	19	119	18.1	83-150
3	3	247	39.1	4	237	9.3	13	167	21.5	141-211
4			194-287	3	277	13.4	26	207	17.1	170-236
5	1	253	-				5	243	15.1	226-260
6	2	405	0.5			405-406	3	273	22.5	245-300
7							7	275	18.3	257-305
8	2	516	8.0			508-524				
9										
10							1	372	-	-
Totals	9			20			114			

Figure 7. Age and growth comparison of
the brook trout and brown trout
captured during the study.



2) The data reported in this study are for a combined sample which includes fish from areas outside those included in Shirvell's sample. Fish from other streams may grow more slowly than those in Stauffer Creek thereby affecting the combined growth rate.

3) The data are for observed rather than calculated lengths and for this reason are subject to seasonal variation. For example, samples of fish captured in the spring may be significantly smaller than same-age fish taken in the fall of the year, at the end of a season's growth.

Despite the foregoing observations, the growth data do indicate a satisfactory growth rate for brook trout in the Red Deer system. The species is readily available to anglers in Stauffer Creek, the Raven River and in Fallentimber and Burnt Timber Creeks. Stauffer Creek particularly, is renowned as a brook trout (as well as brown trout) stream and provides some of the best fly fishing for this species anywhere in Alberta.

Mature brook trout as young as age 2 were among the fish examined in the sample. About 50% of those aged 3 years were mature and all of the fish aged 4 were mature.

Brook trout are fall spawners and probably spawn in late October and in November within the study area. While widely distributed throughout the cold water habitat of the study area, it is likely that most spawning takes place in

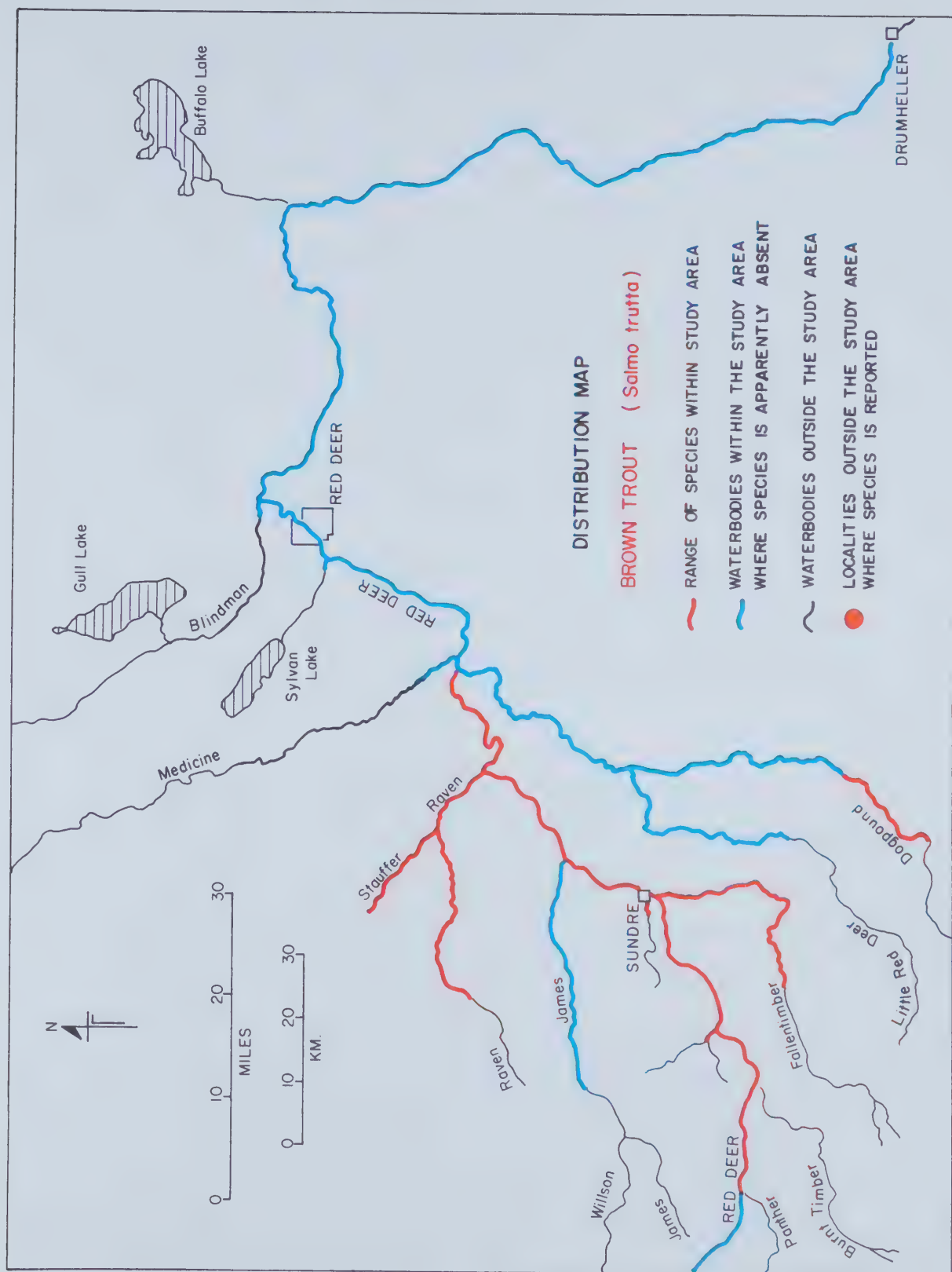
the areas where brook trout are locally abundant, *e.g.*, Stauffer Creek and Fallentimber Creek. However, a few fry were captured in the Red Deer River between the Mountaineer Lodge and Sundre suggesting that some limited spawning takes place in these areas.

Brook trout do not appear to undertake any lengthy mass migrations within the study area. Movements are mostly limited to short distances from feeding areas to suitable spawning and overwintering areas.

Brown Trout

The brown trout, a native of Europe, has been widely introduced into North America. It was first introduced into the Red Deer River drainage (the Raven River) in 1924 and 1925 (Paetz and Nelson, 1970). Its present distribution (Figure 8) includes large populations in the Raven River and the lower and middle reaches of its tributary Stauffer Creek. In the latter, densities up to 801 per mile have been recorded (Shirvell, 1972). It is also abundant in Fallentimber Creek and the upper reaches of Dogpound Creek. While brown trout are occasionally taken in the Red Deer River from the mouth of the Panther River downstream to the mouth of the Medicine River (rarely as far downstream as the city of Red Deer), conditions in the river appear to be marginal for this species and densities are apparently very low.

Figure 8. Distribution of the brown trout
within the Study Area.



As previously indicated, brown trout generally occupy warmer, slower waters than do brook trout, the other abundant salmonid in the Study Area. This generalization, which appears to be valid in most parts of Canada (Scott and Crossman, 1973), is supported by Shirvell's (1972) work on Stauffer Creek, within the Red Deer River Study Area. The brown trout can withstand the less favourable environments characteristic of the lower reaches of streams and has a higher optimum temperature range (65-75 F; Brynildson *et al.*, 1963) than does the brook trout (approximately 55 F; Baldwin, 1956).

The length frequency distribution of brown trout captured during the study is given in Figure 6. The maximum length recorded was 524 mm, for an 8-year old female from the Raven River.

Ages for brown trout were determined by the otolith method. The data are for a combined sample (N=9) of trout taken in several areas: Stauffer Creek (N=3), the Raven River (N=2), the Red Deer River (N=1), Fallentimber Creek (N=2) and Dogpound Creek (N=1). The results (Table 4 and Figure 7) indicate that brown trout grow more rapidly and live to greater age (age 8 compared to age 4) than brook trout. Growth rates estimated from otoliths during this study were far lower than those determined by scales by Shirvell (1972). The reasons for this discrepancy are not clear but probably include those previously listed for brook trout as well as the fact that the sample of brown trout aged

for this study was very small, only 9 fish.

Among the fish examined, all those older than 3 years were mature.

Brown trout are fall spawners and (in the study area) probably spawn from mid-October to mid-November. Shirvell (1972) examined spawning areas on Stauffer Creek on November 2, 1972, and found many redds already completed. It appears that brown trout populations in the study area are relatively stationary and confined to a number of separate areas of suitable habitat on tributary streams. There are no data indicating that brown trout undertake any extensive migrations to spawning grounds although it is likely that some individuals do move short distances (*e.g.*, a few miles) from summer feeding areas to adequate spawning localities.

Where they are abundant, as in the Raven River, Stauffer Creek and Fallentimber Creek, brown trout attract relatively large numbers of fishermen. Because they have the reputation of being among the most difficult sport fishes to angle successfully, the species is particularly attractive to the serious angler. Scott and Crossman (1973) suggest that the brown trout's lesser vulnerability to angling, especially among older fish, may partially explain the larger sizes attained by brown compared with brook trout in those areas where the species occur together (*e.g.*, Stauffer Creek and the Raven River). Marshall and MacCrimmon (1970) suggest

that streams supporting both brown and brook trout and subjected to heavy fishing pressure should result in the establishment of self-sustaining populations of both species, and improve the overall harvest and quality of angling.

Experience in Alberta (Nelson, 1965) indicates that brown trout do well in fluctuating environments such as reservoirs. Similar observations have been made in studies of Swedish reservoirs in which growth of brown trout was better after impoundment than before (Stube, 1958; Runnström, 1964). In addition to an apparently greater physiological tolerance of extremes, it appears that brown trout are more aggressive territorially than other salmonid species (Nelson, 1965) to the detriment of the latter. Nelson suggests that in the Kananaskis River system brown trout have caused a marked decrease in populations of Dolly Varden, brook trout, cutthroat trout, and rainbow trout where their ranges overlap.

Other Trout Species

Two other trout species have been reported from the Red Deer River drainage (Table 2), the rainbow trout and cutthroat trout. Of these, two rainbow trout were collected in a small unnamed tributary of the Red Deer River near Sundre. This species is not native to the drainage and appears to have a very limited distribution. No cutthroat were captured. At present they appear to be confined to

high altitude headwater tributaries outside the scope of this study. If they occur within the study area they must be extremely rare.

Mountain Whitefish

The mountain whitefish is by far the most abundant sports fish in the Study Area (Table 3). The species is widely distributed (Figure 9) in the Red Deer River at least as far upstream as the boundary of Banff National Park. Spawning appears to be confined to the area of the Red Deer River above Damsite 6 but a large segment of the population feeds and overwinters as far downstream as Morrin, some 150 miles downstream of the Damsite.

During the summer period the mountain whitefish is common in the larger tributary streams above Damsite 6 (*e.g.*, the Raven and James Rivers and Fallentimber Creek). Occasional specimens have been taken in the lower reaches of the Medicine and Blindman Rivers (M. Kraft, Regional Fisheries Biologist, Red Deer, Alberta; personal communication).

The length-frequency distribution of the sample of mountain whitefish taken during the course of this study is given in Figure 10. The largest fish was a 372 mm male, age 10, taken in the Raven River near its mouth.

Ages for mountain whitefish were determined from otoliths. The results (Table 4 and Figure 11) are for

Figure 9. Distribution of the mountain whitefish within the Study Area.

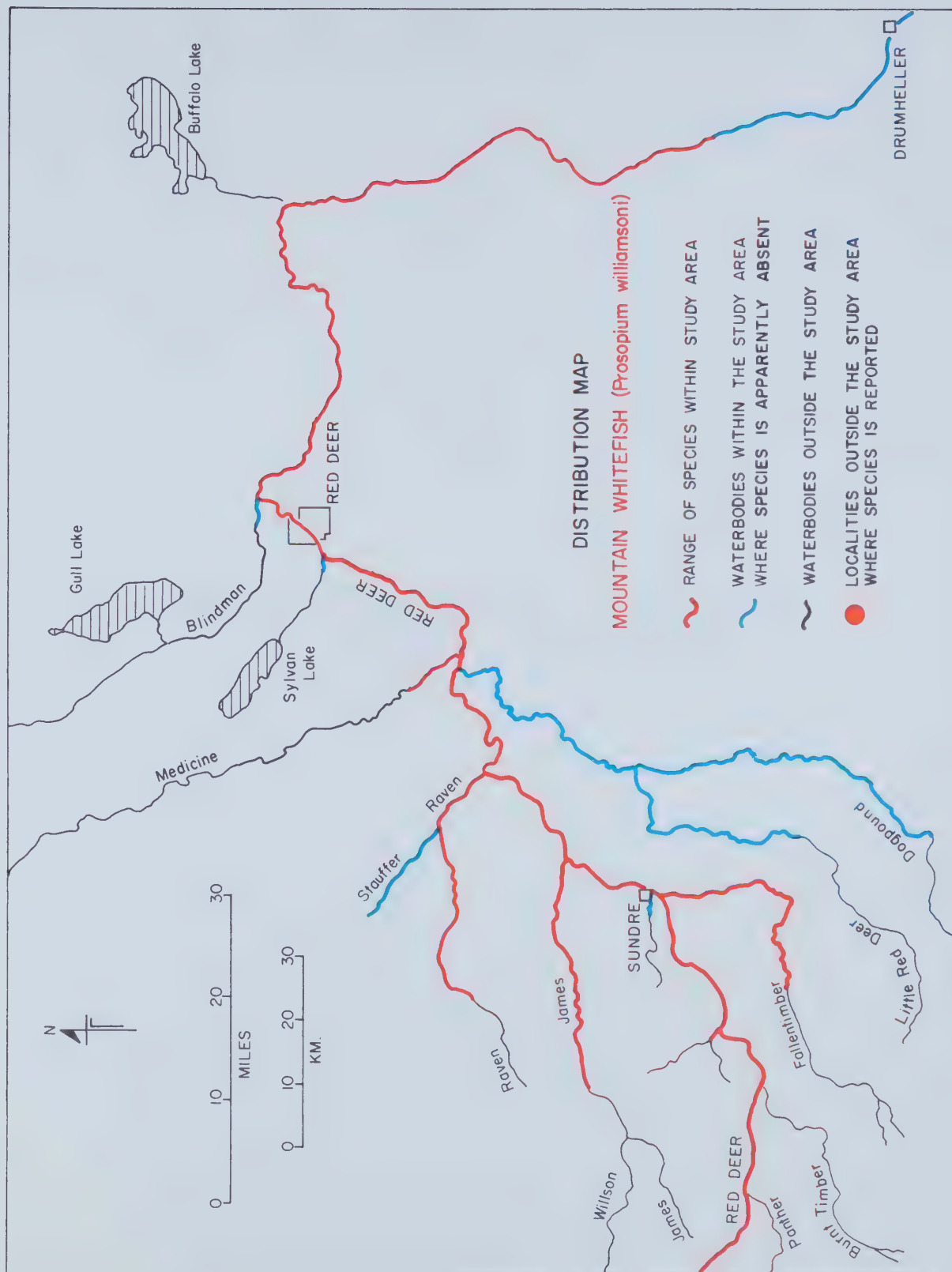


Figure 10. Length frequency of the mountain whitefish captured during this study.

MOUNTAIN WHITEFISH

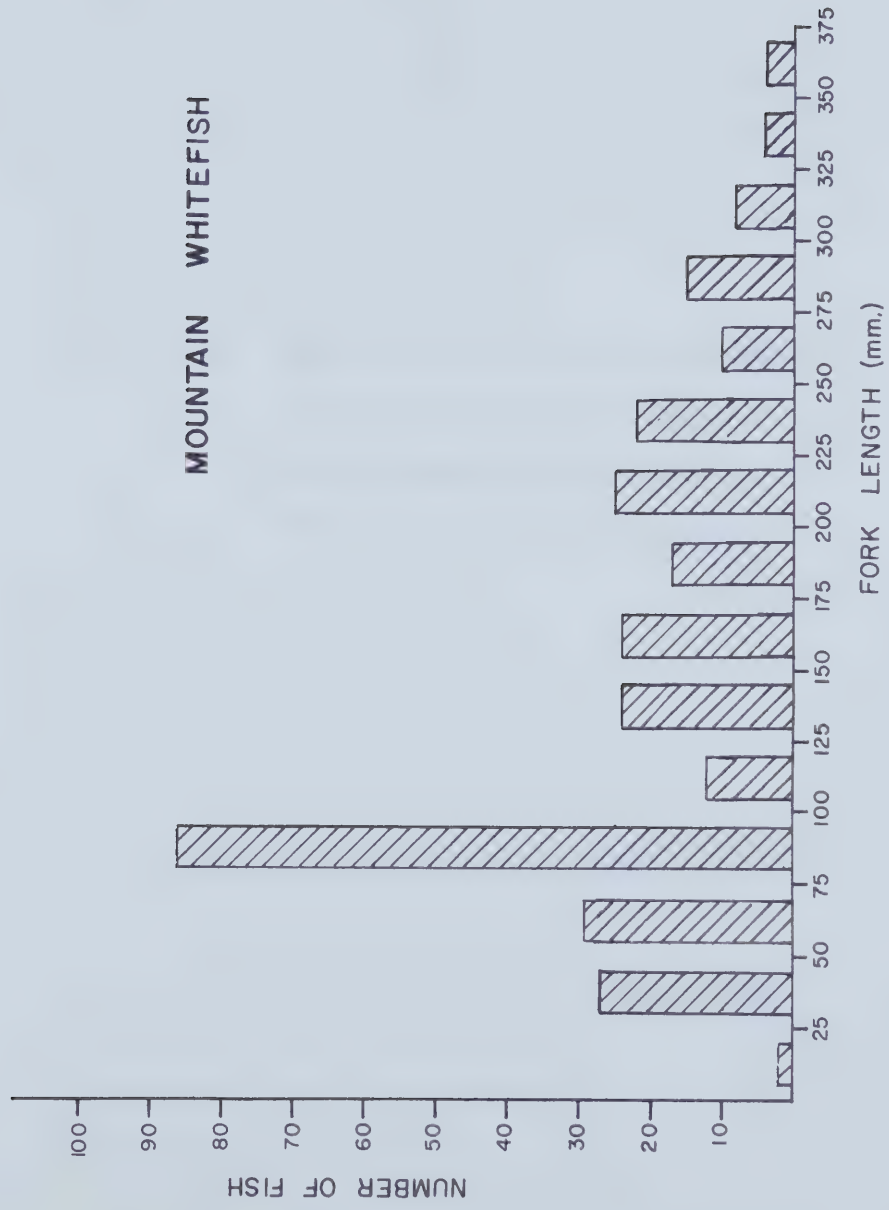
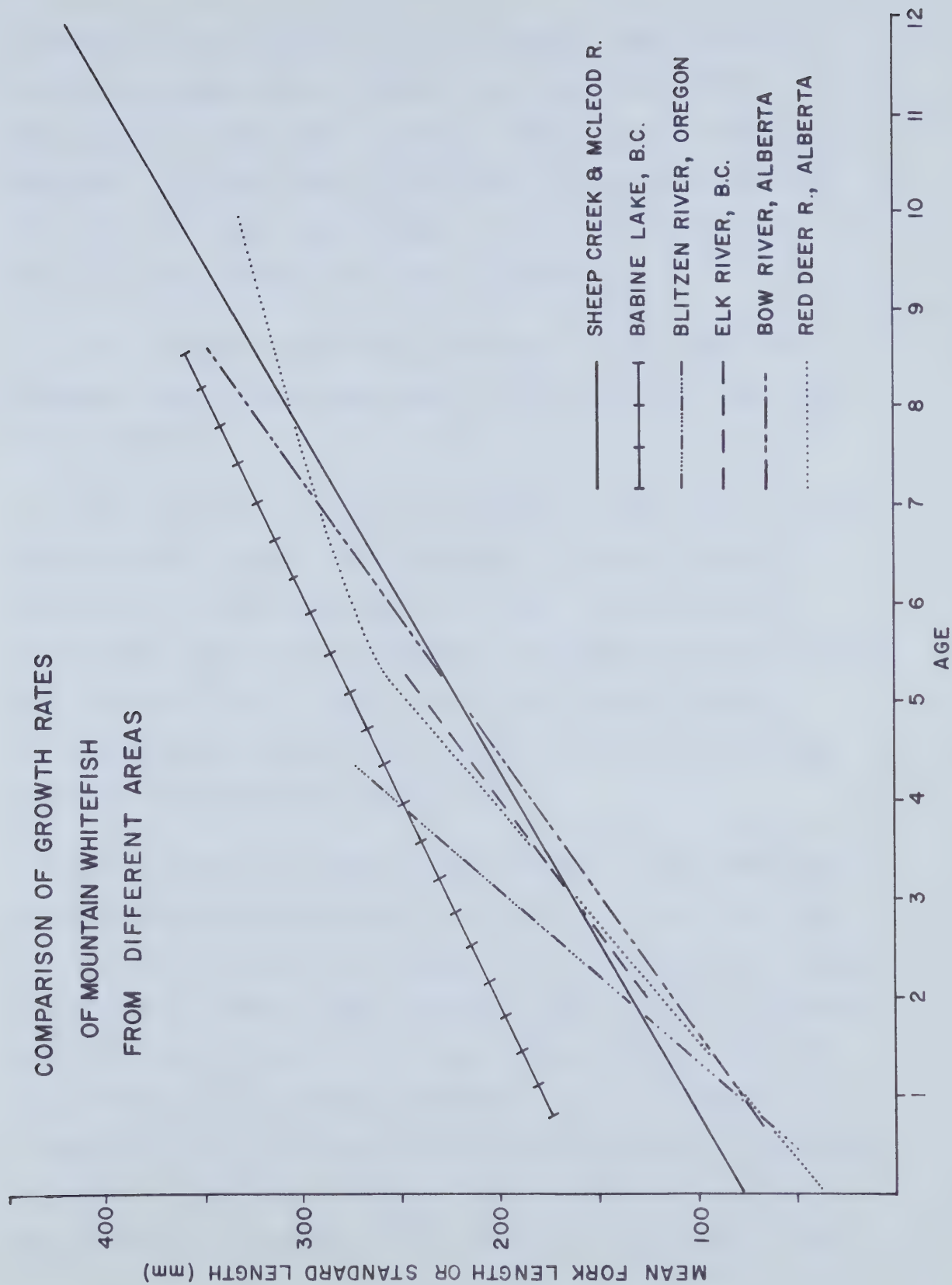


Figure 11. Age and growth of the mountain whitefish from the Red Deer River compared to mountain whitefish from other areas.

COMPARISON OF GROWTH RATES OF MOUNTAIN WHITEFISH FROM DIFFERENT AREAS



a combined sample (N=125) of fish from the Red Deer River (N=88), the Raven River (N=23), the James River (N=4), Fallentimber Creek (N=5) and Brown Creek (N=5). Figure 11 compares the growth rate of the sample from the study area with those of other populations. Growth in the Red Deer River is about average for these populations.

The youngest mature male taken was 3 years old, the youngest mature female was age 4. All fish older than age 6 were mature.

The movements of mountain whitefish within the Red Deer River drainage appear to be complex and involve lengthy migrations for all age classes of fish. It also appears likely that patterns of movement are different for the various age classes of fish. Based upon catch records and the distribution of various life history stages, the following patterns of movement are suggested.

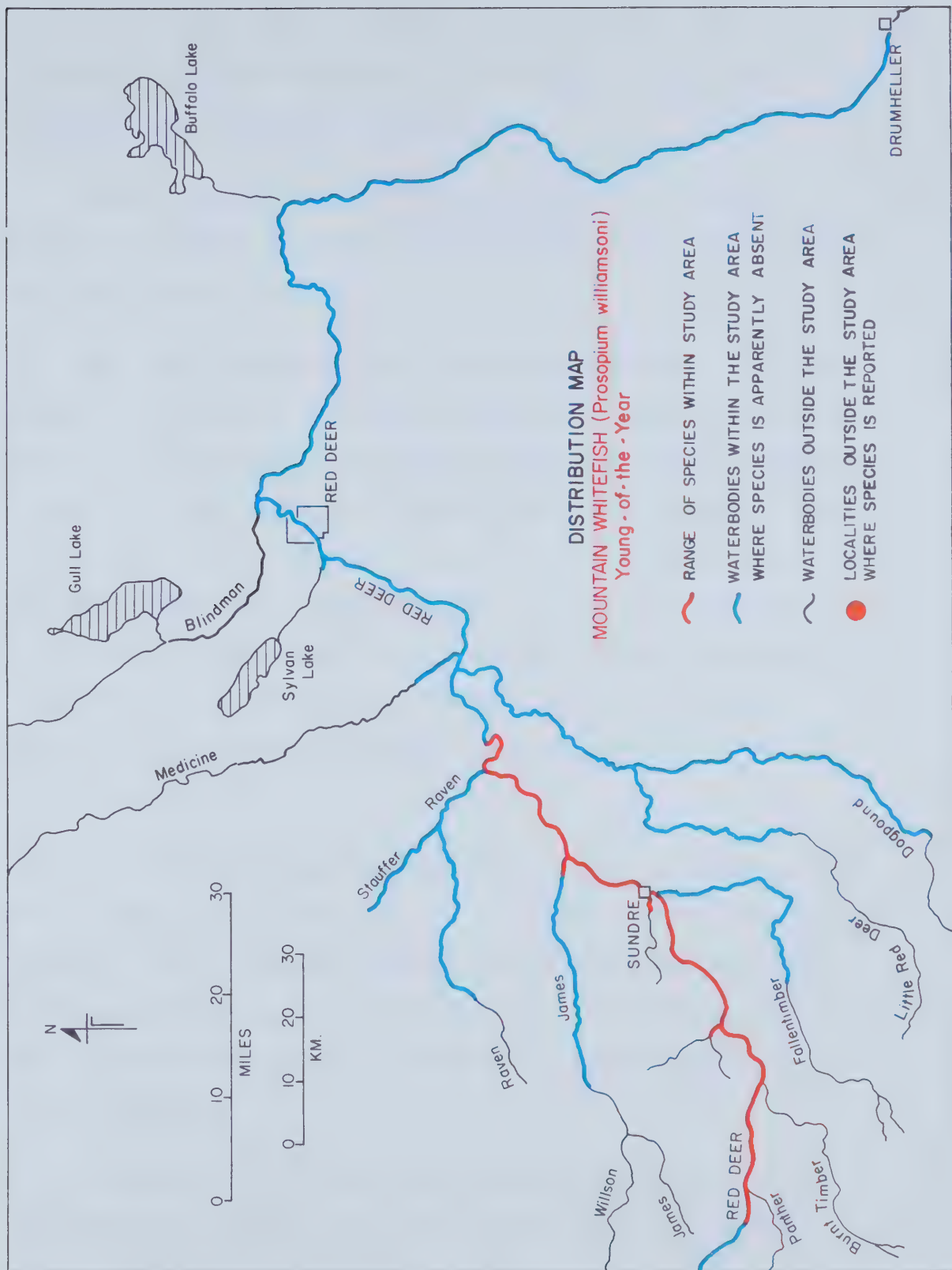
- 1) Young-of-the-year, while they may drift downstream to some extent, are generally concentrated in the vicinity of the spawning grounds throughout the summer and were found in schools in shallow side channels right up until freeze-up when they were forced to move into deeper water. The main concentrations of mountain whitefish fry were found in the vicinity of the Garrington bridge west of Bowden and upstream to about 6 miles above Sundre. Small numbers of fry were found further upstream in the vicinity of the mouth of the

Panther River, indicating some scattered spawning in these areas (Figure 12).

2) Juveniles (*i.e.*, fish one year or older but not yet mature) appear to disperse widely throughout the drainage (Figure 9). They are common in the mainstream of the Red Deer River from its headwaters to as far downstream as Tail Creek. One individual was taken as far downstream as Morrin. Juveniles are also common in the larger tributaries of the Red Deer River upstream of Damsite 7 (Raven River, James River, Fallentimber Creek and Brown Creek). Though juveniles may enter the lowermost reaches of tributary streams downstream of Damsite 7 (*e.g.* the Little Red Deer River, and the Medicine and Blindman Rivers), it appears that they do not utilize these waters to any extent. A fish trap operated by the Fish and Wildlife Division near the mouth of the Medicine River, April 22 to June 1, 1968, captured only eight mountain whitefish among hundreds of fish of other species (M. Kraft, personal communication).

3) There are two categories of mature fish, juveniles maturing for the first time and adult fish which have previously spawned. As previously indicated, juveniles are widely distributed within the drainage and at maturity many must undertake a lengthy migration to reach the spawning grounds. For example, juveniles maturing in the vicinity of Tail Creek, would have to undertake

Figure 12. Distribution of mountain
whitefish young-of-the-year
within the Study Area.



a minimum upstream migration of 90 miles to reach known spawning areas upstream of Damsite 6.

Adult mountain whitefish were found to be widely dispersed (Figure 9) when the field portion of this study was initiated on April 26.

The adult fish remained dispersed throughout the Red Deer River drainage upstream of Damsite 6 until approximately the first of September when they began appearing in angler's catches in the vicinity of Sundre and the Garrington bridge (Table 5). On October 1, 100 to 300 meter stretches of the Red Deer River were swum with the aid of a wet suit and snorkle at five mile intervals from the Big Horn Creek campground down to about 6 miles above Sundre. Visibilities were excellent (in excess of 50 feet) and no concentrations of fish were observed.

On October 3, approximately 400 meters of the Red Deer River were swum in the vicinity of Sundre and the Garrington bridge. Visibility was limited to 3-4 feet but many adult-size mountain whitefish were observed. No spawning activity was observed and the fish appeared to be moving randomly about the pools.

On October 11, eight mature mountain whitefish were captured by drifting a gillnet through pools and riffles where fish were thought to be spawning. Six fish were taken 2 miles upstream from Sundre. Five of these fish were ripe,

Table 5. Summary of information obtained from anglers interviewed during Red Deer River flow regulation proposal fisheries study, 1974.

Date	# Anglers	Hours Fished	# Fish Caught	Species	One-way Distance Travelled	Residence	Location	Region
May 5	5	15	2	brown trout	75 mi	Calgary	Fallen Timber	I
Jun 1	4	8	4	longnose dace	45	Red Deer	Raven River	I
				2 walleye				
2	6	24	11	2 pike	24	Innisfail	Raven River	I
				1 brown trout				
2	5	15	10	10 white suckers	30	Eckville	Raven River	I
				white suckers				
17	2	10	19	brook trout	5	Caroline	Staufer Creek	I
22	2	8	3	brown trout	107	Calgary	Staufer Creek	I
22	2	10	16	brown trout	107	Calgary	Staufer Creek	I
30	2	8	3	1 pike	24	Innisfail	Raven River	I
30	2	3	0	2 white suckers	24	Innisfail	Raven River	I
				white suckers				
30	3	7.5	1	mountain white-fish	15	Staufer	Raven River	I
30	2	3	0	-	45	Red Deer	Raven River	I
				-				
30	2	4	0	-	100	Calgary	Red Deer River	I
30	2	2	0	-	20	Bowden	Red Deer River	I
30	2	3	0	-	45	Red Deer	Raven River	I
14	4	4	0	-	20	Bowden	Red Deer River	I
14	2	1	0	-	68	Calgary	Red Deer River	I
14	5	10	15	5 goldeye	50	Red Deer	Red Deer River	I
14	4	4	0	10 white suckers	100	Calgary	Red Deer River	I
				white suckers				
14	3	6	9	goldeye	15	Markerville	Raven River	I
14	6	24	7	goldeye	53	Rimbey	Raven River	I
17	2	4	1	Dolly Varden	100	Calgary	Red Deer River	I
17	2	4	0	-	10	Sundre	Red Deer River	I
17	2	2	0	-	30	Eckville	Raven River	I
18	2	10	9	brown trout	112	Calgary	Raven River	I

(continued)

Table 5. Continued

Date	# Anglers	Hours Fished	# Fish Caught	Species	One-Way Distance Travelled	Residence	Location	Region
Jul 18	4	4	0	-	24	Innisfail	Raven River	I
23	1	10	0	-	6	Innisfail	Red Deer River	II
23	1	5	0	-	30	Caroline	Red Deer River	II
24	2	6	12	mountain whitefish	10	Sundre	Red Deer River	I
25	1	1	1	white sucker	120	Edmonton	Red Deer River	I
25	2	4	0	-	24	Innisfail	Raven River	I
25	1	4	1	brook trout	246	Medicine Hat	Red Deer River	I
30	1	2.5	2	longnose dace	20	Bowden	Red Deer River	I
Aug 16	6	12	1	white sucker	8	Bowden	Red Deer River	I
21	2	6	2	Dolly Varden	10	Red Deer	Red Deer River	II
27	2	3	3	goldeye	20	Bowden	Red Deer River	I
27	2	2	2	mountain whitefish	10	Sundre	Red Deer River	I
27	1	1	1	pike	30	Innisfail	Raven River	I
Sep 5	2	3	5	mtn. whitefish	20	Bowden	Red Deer River	I
12	1	1	5	mtn. whitefish	100	Calgary	Red Deer River	I
12	3	1.5	0	mtn. whitefish	20	Bowden	Red Deer River	I
20	1	3	1	mtn. whitefish	20	Bowden	Red Deer River	I
20	1	2	1	mtn. whitefish	12	Dickson	Red Deer River	I
Oct 16	2	12	6	mtn. whitefish	20	Bowden	Red Deer River	I
16	1	2	1	mtn. whitefish	20	Bowden	Red Deer River	I
17	2	10	4	mtn. whitefish	20	Bowden	Red Deer River	I
18	2	12	1	brown trout	20	Bowden	Red Deer River	I
			5	mtn. whitefish		Bowden	Red Deer River	I
Total				Total fish	Total distance			
Total groups				47	2054			
Total anglers				120				

partially-spawned males and one was a recently spawned female. Another recently spawned female was taken five miles below Sundre and a third was taken at the Garrington bridge. In addition, anglers at Sundre had in their possession two ripe males and mentioned that they had started catching ripe fish, both males and females, about one week earlier.

By October 18, mature fish appeared to be absent from the spawning areas and only juveniles could be taken by drifting a gillnet through the same riffles and pools where fish in spawning condition had been taken earlier.

The same stretches of the Red Deer River, from 2 miles above Sundre to 5 miles below the Garrington bridge, were again sampled on November 6 and no fish were observed or taken. However, further downstream, one mile below the Innisfail bridge, 13 mature mountain whitefish were taken. These fish, 8 males and 5 females had all spawned this season (one female had retained eggs) and since this location is below the known spawning grounds and below any area where fry have been taken, it seems likely that these fish were moving downstream to overwintering areas.

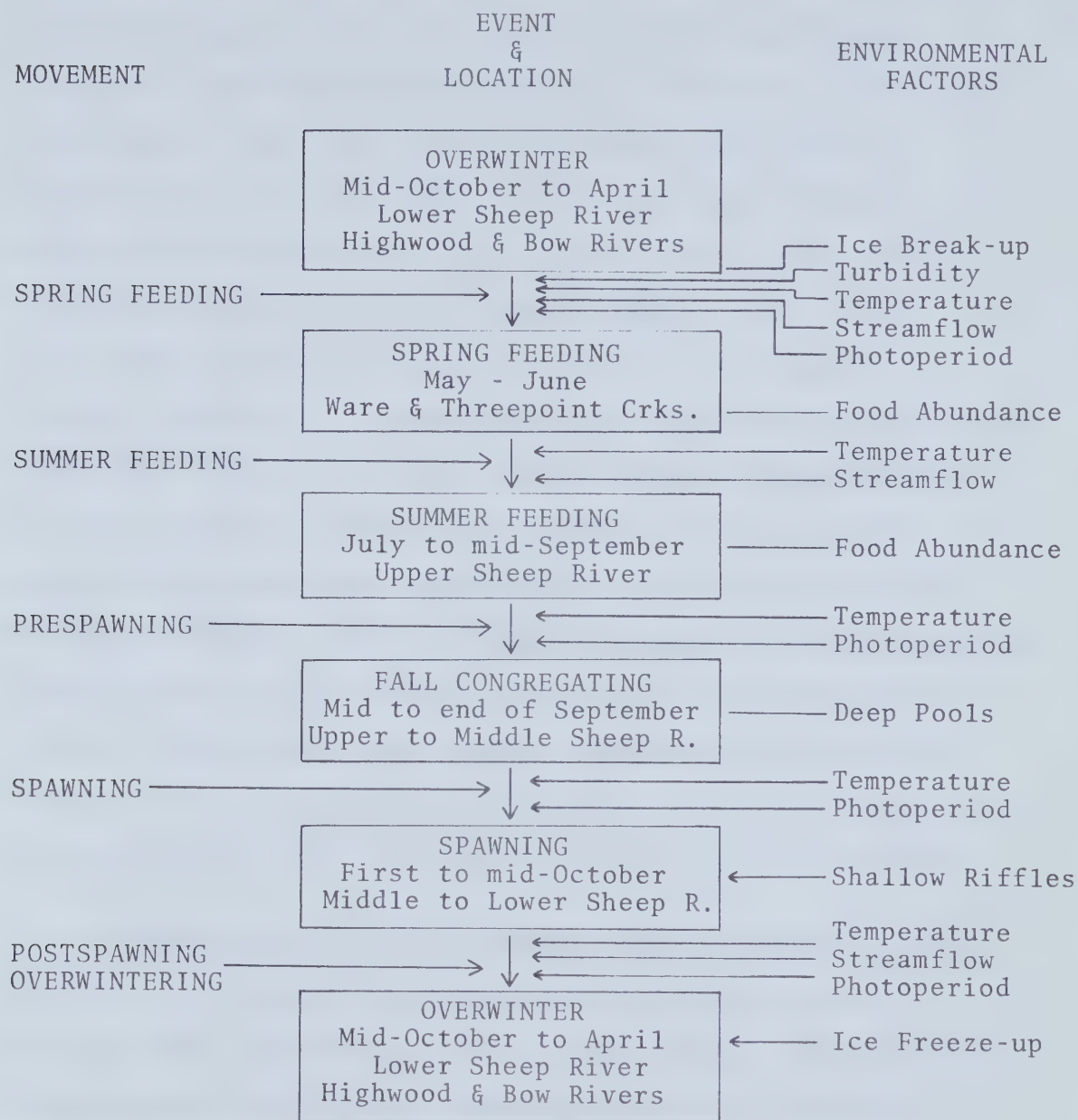
The following day, November 7, 12 additional mature fish were taken at Penhold and 6 more were captured at the water treatment plant about 6 miles below the City of Red Deer. This further indicates a post-spawning downstream migration by adult fish to overwintering areas.

Such complex migration patterns appear to be characteristic of stream-dwelling mountain whitefish populations in Alberta and have been described by Thompson (1974) for fish in the Sheep River-Highwood River System (his observations are summarized in Figure 13). Thompson notes a concentration of mature fish in the mid-regions of the Sheep River about mid-September followed by spawning the first two weeks of October and a post-spawning downstream migration to overwintering areas in the lower Sheep and Highwood Rivers and in the Bow River.

These migration patterns allow this species, which is a cold water species in terms of its spawning requirements, to utilize extensive areas of warm water habitat during at least a portion of its life history. It has the following advantages:

- 1) It greatly increases the energy resources available to the population. This is true, not only because the area of exploitation is greater but because the biological productivity of the downstream feeding areas is higher due to high temperatures and greater nutrient loadings (Table A-1).
- 2) There is a reduction in intraspecific competition because during the summer, a large proportion of the juvenile and adult fish are dispersed away from the major rearing areas for young-of-the-year.

Figure 13. Diagrammatic representation of the movements of adult mountain whitefish in the Sheep River with suggested related and controlling factors (from Thompson, 1974).



The mountain whitefish is, as indicated in Table 3, the most abundant cold water sports species in the Red Deer River drainage. It is also the cold water species most frequently taken by anglers (Table 5) especially during the late summer, early fall period. Overall, the species constituted 32% of the fish in the creel census sample. The species has a small mouth and requires specialized angling techniques including the use of very small hooks, with flies and/or bait (principally earthworms and maggots). For this reason it is seldom taken by casual and inexperienced fishermen. Though the flesh of the mountain whitefish is highly palatable, populations in Alberta are very much underutilized and most could tolerate substantial increases in angler harvest. With increasing population and increasing fishing pressure on the more popular trout and char, the species could assume much greater importance if a publicity campaign were undertaken to apprise potential fishermen of its availability and the methods by which it can be caught.

The mountain whitefish occupies lake as well as stream habitats and appears to do well in impounded streams. Nelson (1965) describing mountain whitefish in the Kananaskis River system stated that, "mountain whitefish showed no signs of being unfavourably affected by hydroelectric development or other species of fish, and their growth rate has increased since 1947." Nelson found that in Barrier Reservoir, mountain whitefish comprised about 85% of the sports fish catch in 1961. It should be noted however, that

Nelson did not consider the possible effects of disruption of traditional migration patterns on mountain whitefish populations. Nothing is known of the migration patterns of this species prior to the construction of the four Kananaskis Dams beginning in 1936.

Warm Water Sports Species (Group 2)

Northern Pike

The northern pike is the largest of the warm water sports species found within the study area. A twelve-year-old, 740 mm (29 inches) individual, captured near the mouth of the Raven River, was the largest fish taken during the course of this study, but larger pike undoubtedly occur.

Pike are distributed throughout the study area from Drumheller to a point just upstream of Damsite 7 (Figure 14). They inhabit both the Red Deer River itself and its larger tributaries including the Blindman, Medicine, Little Red Deer and Raven Rivers and the lower portion of Stauffer Creek. The species typically frequents the slower, warmer areas of streams, quiet pools, backwaters and sloughs.

The length frequency of pike examined in detail during this study is indicated in Figure 15. The fish included in the small sample (N=17) were taken near the mouth of the

Figure 14. Distribution of the northern
pike within the Study Area.

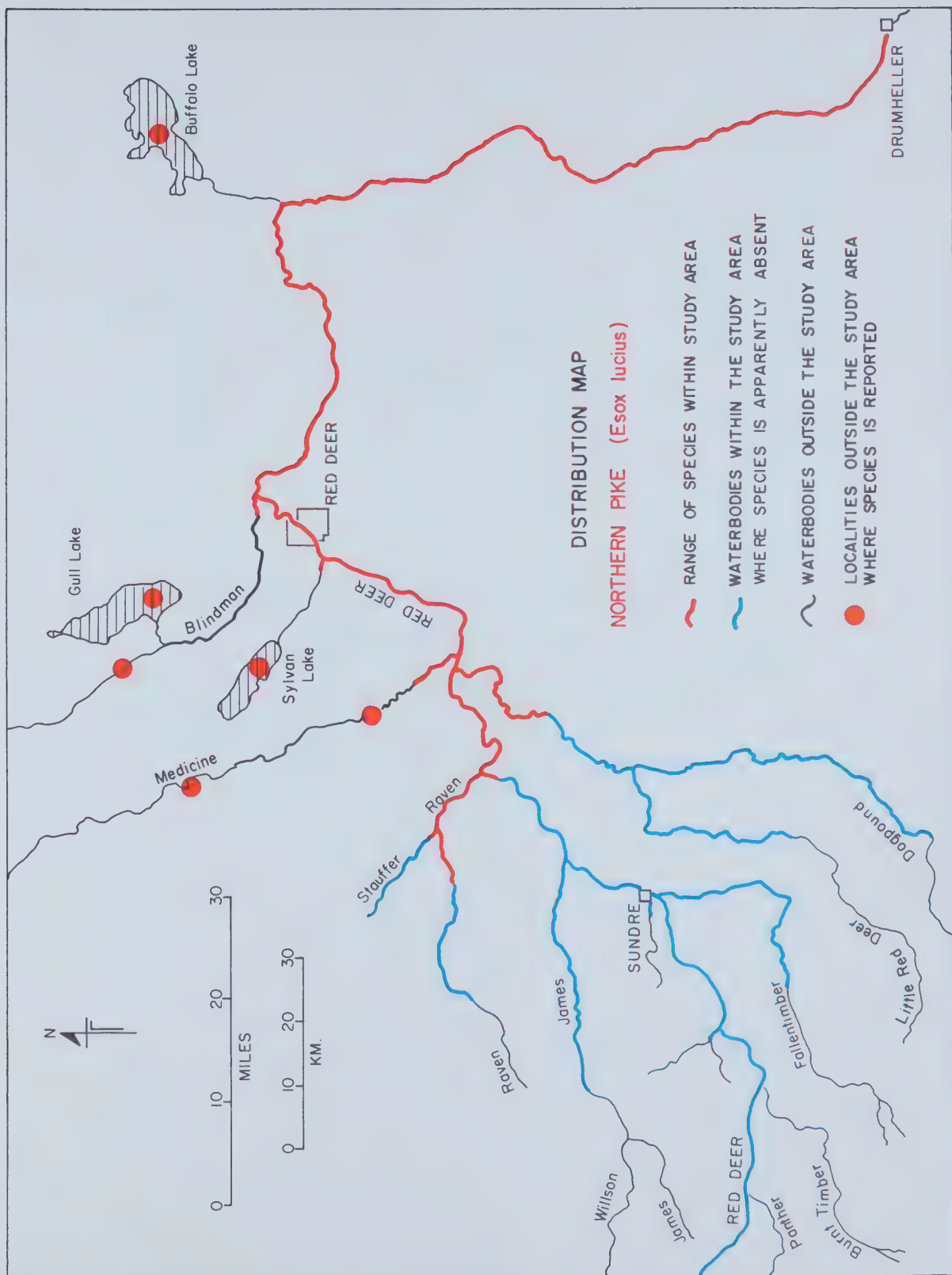
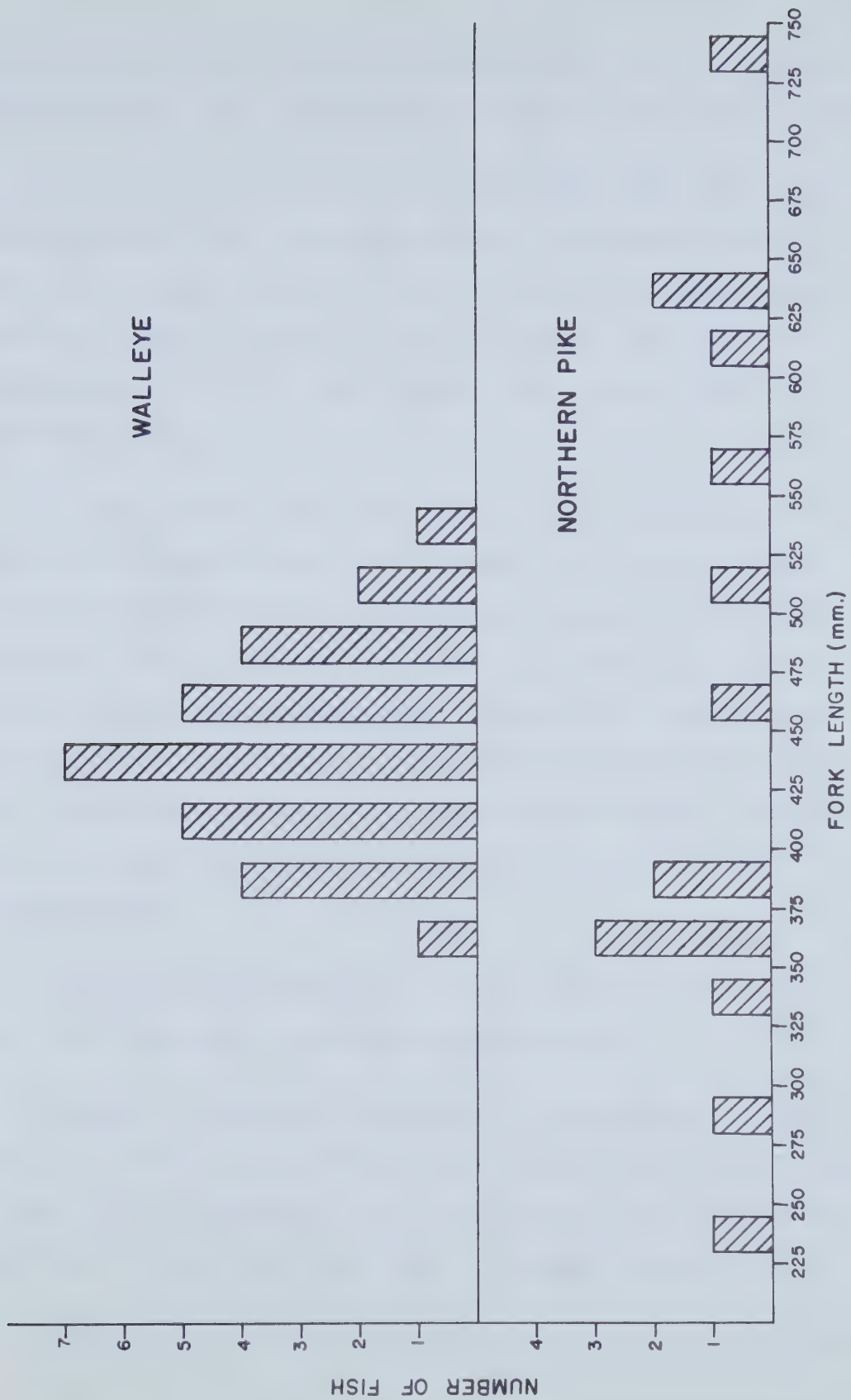


Figure 15. Comparison of the length
frequency of northern pike and
walleye captured during the
study.



Raven River (N=11), in Stauffer Creek (N=2), in the Little Red Deer River (N=2), and in the Red Deer River itself (N=2).

The ages of pike were determined from scales as their otoliths were found to be unreadable. The observed growth rate for the aged sample (N=11) is indicated in Figure 16. The data (Table 6) indicate that the pike is the fastest growing species in the Study Area. The youngest fish captured was age 3.

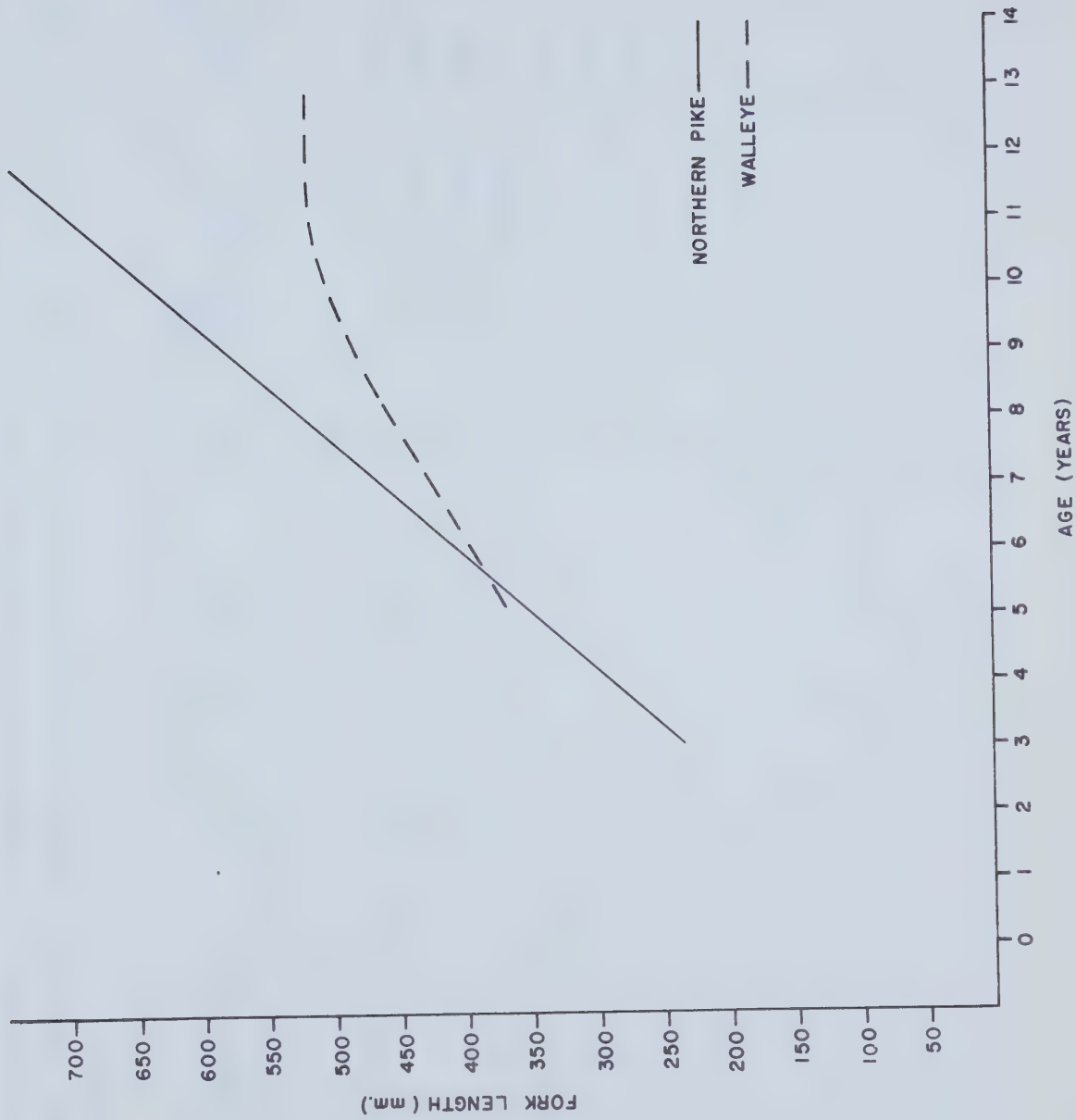
No young-of-the-year were taken during sampling in the Study Area though several of the female fish taken in the Raven River appeared to have recently spawned. A special effort to locate young-of-the-year pike within the Raven River drainage was unsuccessful. These facts suggest that the major spawning locations for pike lie outside the Study Area, possibly associated with the larger tributary streams, *e.g.* the Little Red Deer, the Medicine River, and the Blindman River.

All pike older than age 6 in the sample were mature while all pike aged 4 and under were immature.

Nothing is known of the details of migrations of pike within the Study Area although it is likely that they do move at least short distances from overwintering areas to favoured spawning locations and from there to summer feeding areas.

Although the pike is the largest sports species in the

Figure 16. Age and growth comparison of the northern pike and walleye captured during the study.



study area, locally abundant and easily caught, it is not especially favoured by Alberta anglers who generally consider it to be inferior to trout, char and walleye as a sport and food fish.

The pike is well adapted to an existence in lakes as well as streams. In the former, the species is most abundant in warm, shallow, heavily vegetated bays and marshy areas where it spawns in the spring on aquatic vegetation and where it feeds during the summer. Pike might do well in a reservoir, such as that which would form upstream of Site 7, with an extensive perimeter and large areas of shallow water. However, this would depend in large part on the availability of vegetation suitable for spawning and on the maintenance of stable water levels during the ice-free season, particularly during the sensitive spawning and incubation period in the spring from April to May. Typically, fluctuating reservoirs have little development of littoral vegetation suitable for spawning. In addition, Scott and Crossman (1973) report that egg mortalities as high as 99% have been attributed to stranding as the result of lowering water levels. Mortalities might also result where spawning areas were flooded and covered with many feet of colder water.

Mooneye and Goldeye

The mooneye and goldeye are two closely related species,

both of which are found within the study area. They can be distinguished by the number of dorsal rays (not more than 10 in goldeye and 10 to 14, usually 12, in mooneye) and by the placement of the origin of the dorsal fin (opposite or behind the origin of the anal fin in goldeye and anterior to origin of anal fin in mooneye). Most sports fishermen do not distinguish the two species. Very little is known of the biology of the two species in Alberta and, in fact, the mooneye was not described from the province until 1974 (Roberts, 1974). The mooneye is described as being less tolerant of silted habitats than the goldeye and its decline in Ohio has been linked to increasing turbidity (Trautman, 1957).

The distributions of the two species in the Study Area are indicated in Figures 17 and 18. Both species occur as far upstream as the Raven River where they were abundant at midsummer. A single goldeye was taken in the Red Deer River approximately 1/2 mile upstream of the mouth of the Raven River during the same period. No juveniles or young-of-the-year were captured anywhere in the study area, only mature adults.

The length-frequencies of the samples are indicated in Figure 19. The length distribution of the sample of mooneye (234 to 270 mm) was smaller than, and did not overlap, that of the sample of goldeye (292 to 392 mm).

Figure 17. Distribution of mooneye within
the Study Area.

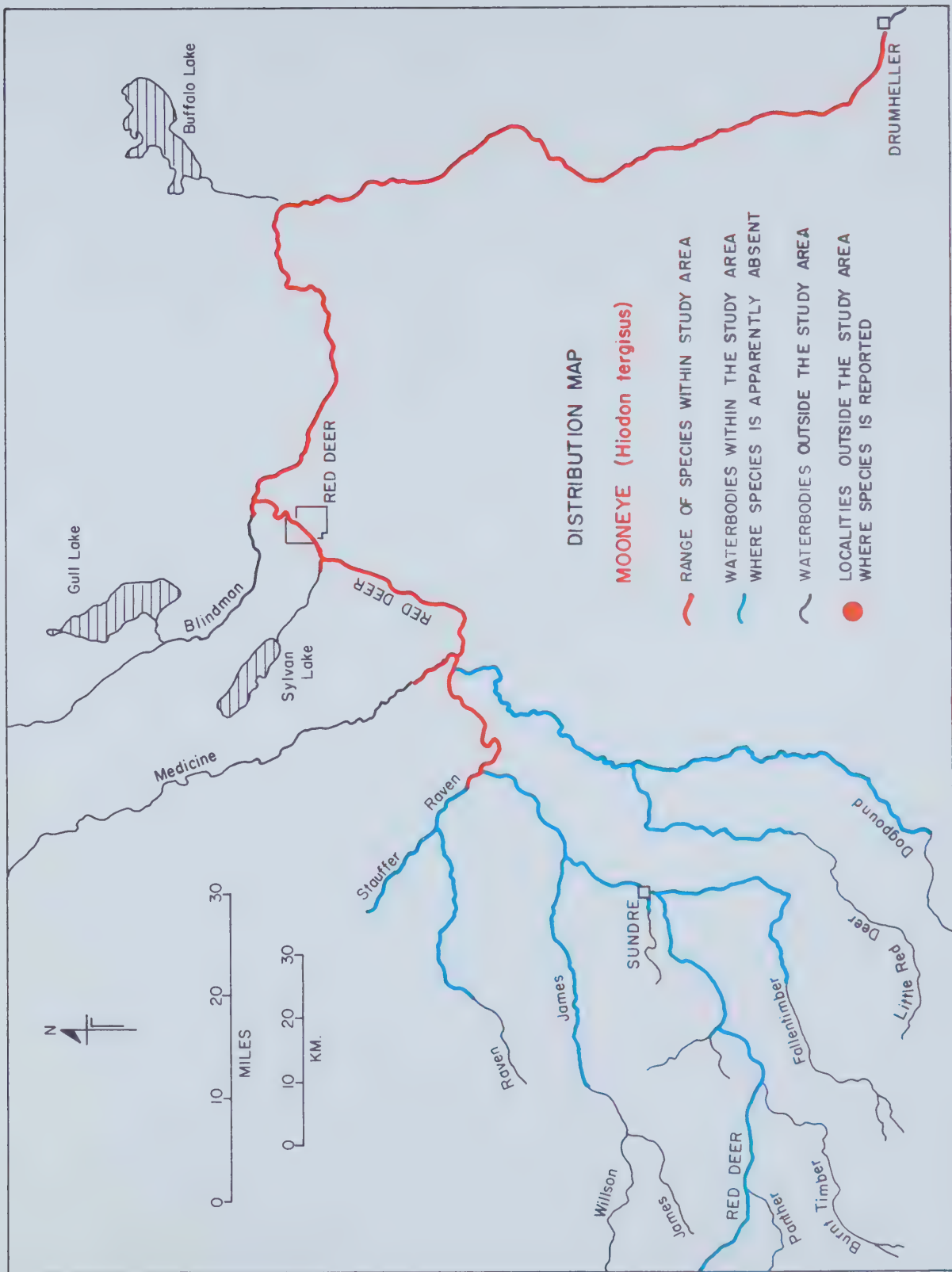


Figure 18. Distribution of goldeye within
the Study Area.

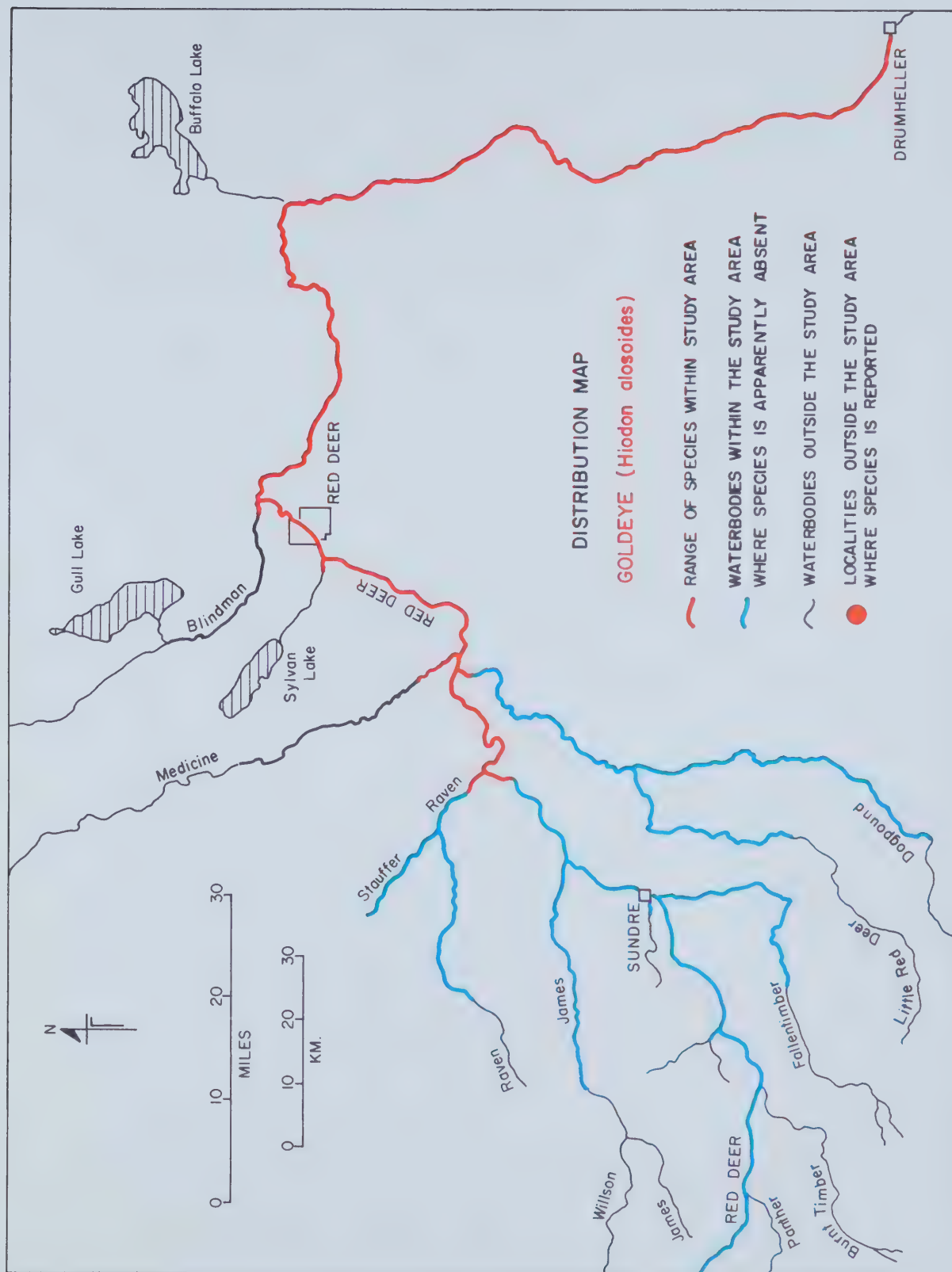
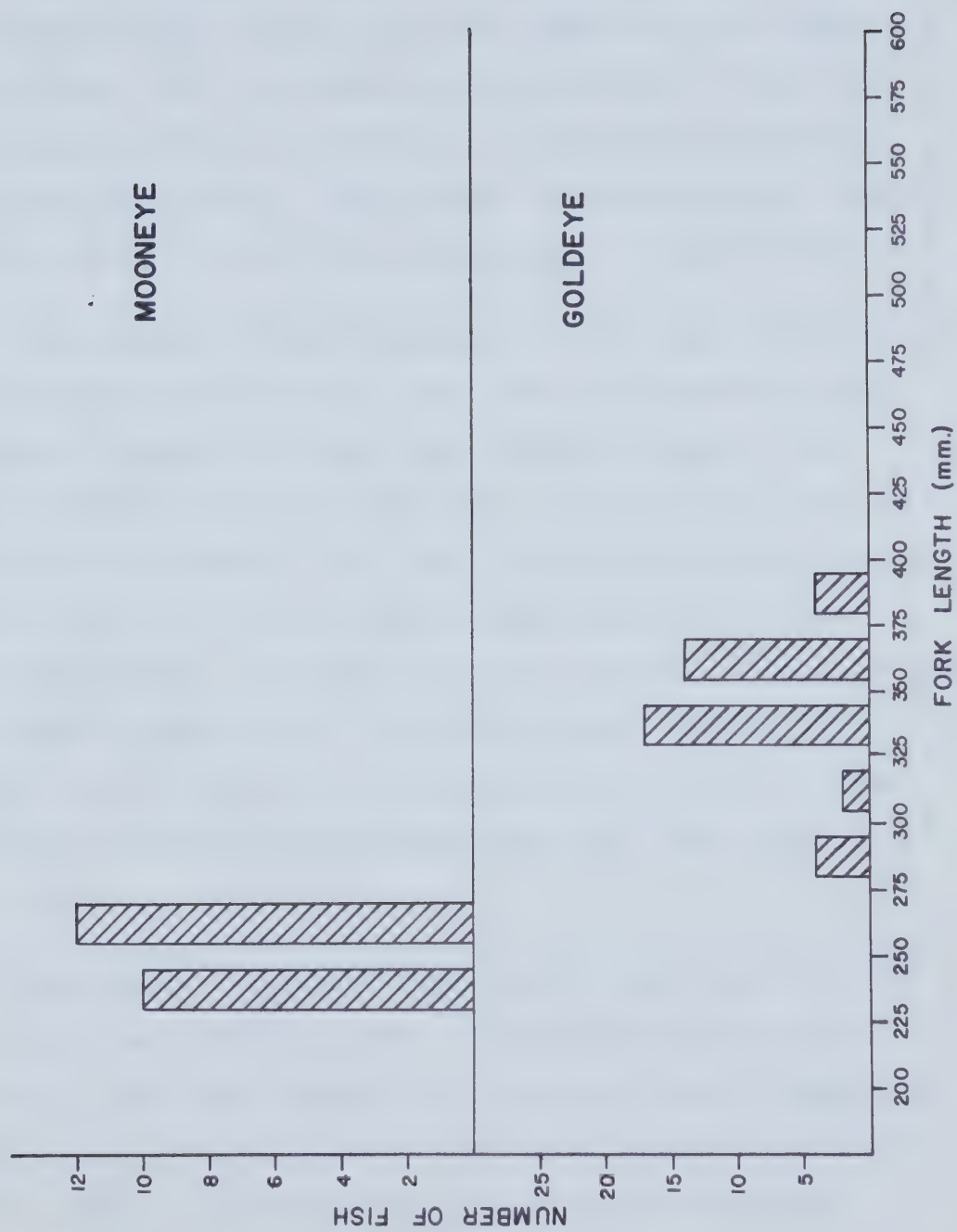


Figure 19. Comparison of the length
frequency of mooneye and goldeye
captured during the study.

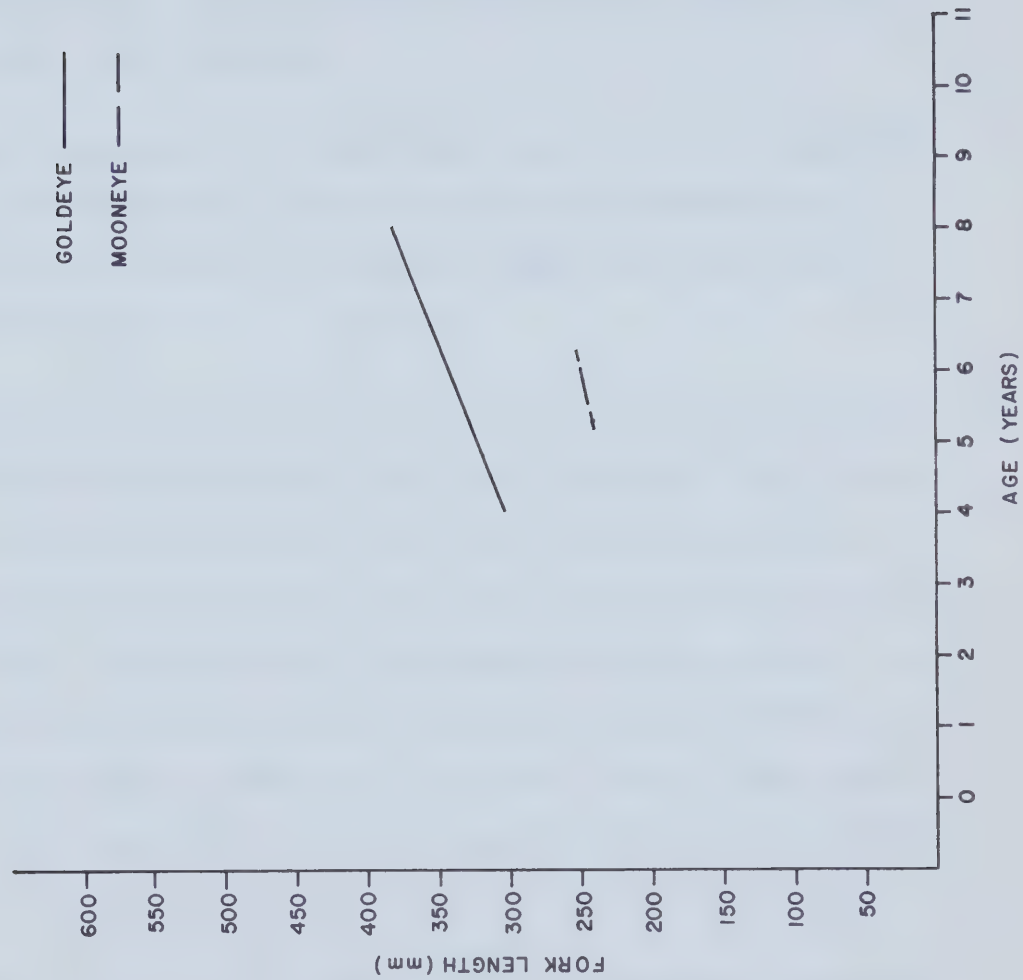


Samples of both species were aged from scales. The aged goldeye were a combined sample (N=30) from the Raven River (N=22) and from various sites on the Red Deer River (N=8). The mooneye sample (N=22) was taken from the lower reaches of the Raven (N=12) and Medicine Rivers (N=10). The data (Figure 20 and Table 6) indicate that mooneye are smaller than same-age goldeye. The youngest mooneye were age 5 and goldeye age 4. As previously indicated, all were mature.

Both species are spring spawners. The spawning sites of the population found in the study area are unknown but the absence of young-of-the-year and juveniles suggest that spawning takes place far downstream. It is likely that the mature fish captured in the study area have moved into the area as part of a summer feeding migration from distant spawning grounds. A similar situation appears to occur in the North Saskatchewan River. Patterson (1966) reports that goldeye do not successfully reproduce in the Edmonton area and do not frequent the Edmonton area until they are 3 or 4 years old.

Both species appeared in catches in the Raven River in the latter half of July, 1974. Goldeye were absent after August 20, 1974, but mooneye were taken as late as August 29. The fish had presumably moved downstream to overwintering areas. There is other evidence of extensive downstream movements. M. Kraft (personal communication) reports tagging

Figure 20. Comparison of the age and growth of mooneye and goldeye captured during the study.



a goldeye in May at Trochu which was captured 90 days later 309 miles from the tagging locality in the South Saskatchewan River 125 miles upstream of its confluence with the Red Deer River. Two others tagged at Trochu were recaptured 110 and 116 miles up the South Saskatchewan River about 300 miles from the tagging point. The recapture dates were 54 and 60 days respectively after tagging.

Other tagged goldeye have been captured at the tagging location one year later, indicating that no movement has occurred or that goldeye follow the same migration routes from year to year.

Goldeye and mooneye are an important constituent of the sports fishery downstream of the City of Red Deer (M. Kraft, personal communication) and are locally important at the mouth of the Medicine River and in the lower stretches of the Raven River. Conversations with anglers in the vicinity of Drumheller and Morrin indicate that the goldeye is the most sought-after sports species in the area. It is likely that many of the individual fish which anglers identify as goldeye are in fact, mooneye.

There appears to be nothing in the available literature describing the effects of impoundment on populations of either species.

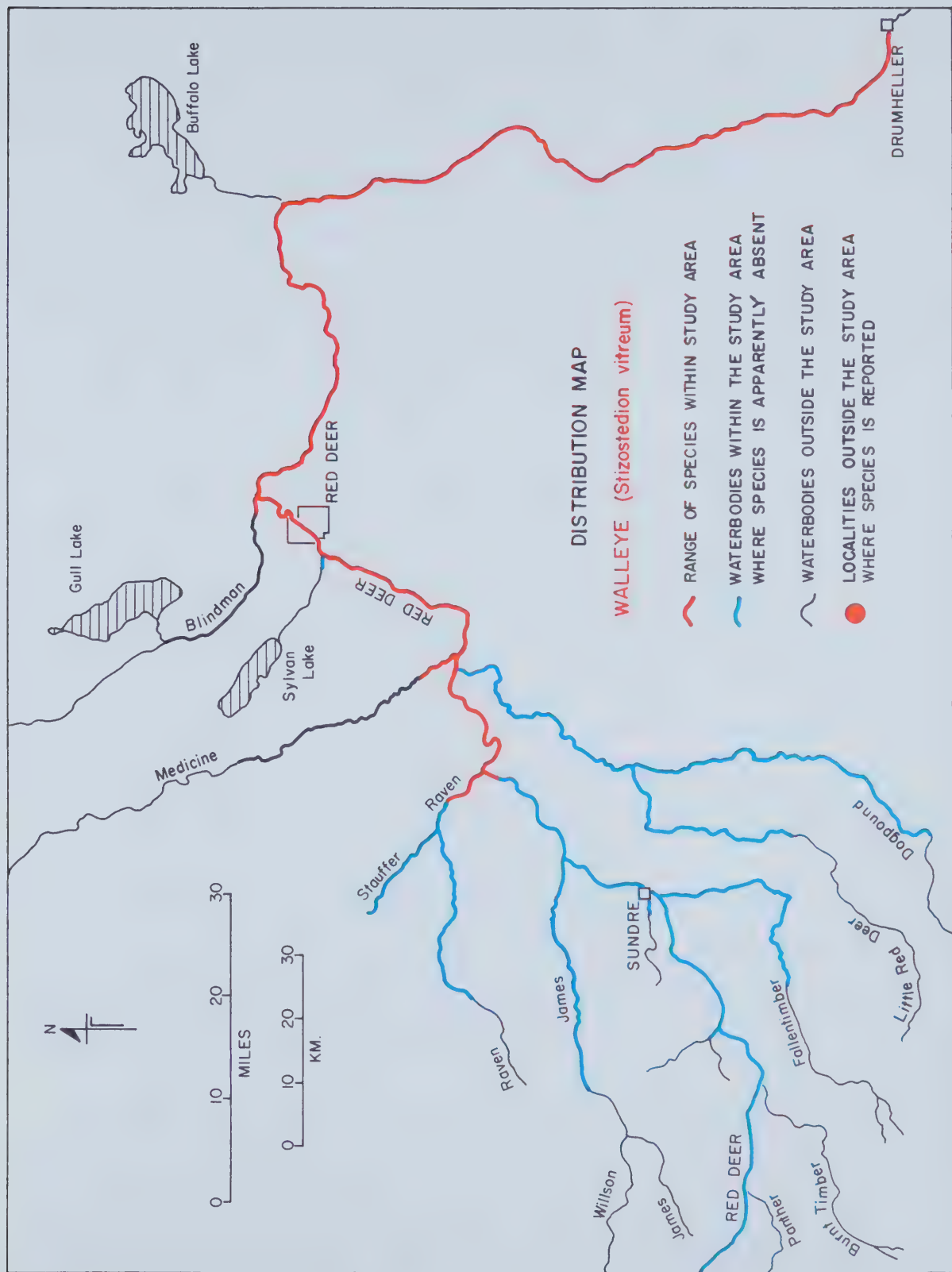
Walleye and Sauger

The walleye and sauger are another pair of very similar species, both of which occur in the study area. Externally, they can be distinguished by the spotting which is found on the first dorsal fin of sauger greater than 6 inches in length but is absent in walleye and by the presence of a white edge on the lower lobe of the caudal fin of walleye which is absent in sauger. Anglers commonly mistake sauger for small walleye. Within the Study Area walleye appear to be more numerous than sauger. Only a single sauger was captured, at a location approximately 6 miles downstream of the City of Red Deer. However, Paetz and Nelson (1970) indicate that the lower Red Deer River is one of the better sauger waters in the province. This reflects the sauger's preference for slow-moving, turbid rivers (Scott and Crossman, 1973).

The distribution of walleye is indicated in Figure 21. This species is found in the lower reaches of the Raven River, the Medicine River and Blindman River and in the mainstem of the Red Deer River from just above its confluence with the Raven River to Drumheller and beyond. Details of the distribution of sauger are unknown.

The length frequency of the sample of walleye collected during the course of this study is presented in Figure 15. All of the fish captured were either mature adults or large juveniles. Early life history stages were absent suggesting

Figure 21. Distribution of walleye within
the Study Area.



that rearing takes place outside the study area. The single sauger collected was a mature male 405 mm in length.

The age of walleye was determined from otoliths. Growth data are presented in Table 6 and Figure 16. A comparison of these data with those summarized by Carlander (1950) indicates that walleye in the study area have a growth rate which is about average for the species. The youngest mature fish in the sample were age 5.

Both walleye and sauger spawn just after ice-out in the spring. In streams, the former typically spawn in white water in the vicinity of rapids, falls or dams. Such areas occur in the Red Deer River system within the Study Area. A ripe male was captured in the Raven River May 22, 1974 and a recently spawned female on June 7 but there is no direct evidence of spawning within the study area and no young-of-the-year or other early life history stages were ever taken.

The major seasonal migration of walleye and sauger is the spring spawning run. However, like other stream-dwelling species, they undertake less well-defined movements to summer feeding areas and overwintering areas.

Walleye and sauger are both excellent food fishes and in many parts of North America are much sought after by anglers. However, only a few of the anglers interviewed during the course of this study had walleye in possession and none had sauger. Most of the anglers interviewed appeared to be

unaware of the presence of these species and of the best methods for angling them. It would appear that the level of exploitation of walleye, in particular, is low in comparison with the size of the population.

Important Non-Sports Species

The following are brief life histories of non-game species, found in the Study Area, which are important because of their abundance and wide distribution. They may influence populations of the more valuable game species both as competitors and as prey species.

The Suckers

Four species of sucker were taken during the course of this study. These were, in order of abundance, white, longnose, and mountain suckers and the shorthead (northern) redhorse. The two with the widest distribution are the white and longnose sucker which are abundant in the mainstem of the Red Deer River and in its tributaries throughout the Study Area (Figures 22 and 23). The mountain sucker, as its name implies, was most abundant in the faster moving segments of the drainage becoming less common downstream of the damsites though occasional specimens were taken as far downstream as Trochu (Figure 24). The shorthead redhorse had a distribution

Figure 22. Distribution of white sucker
within the Study Area.

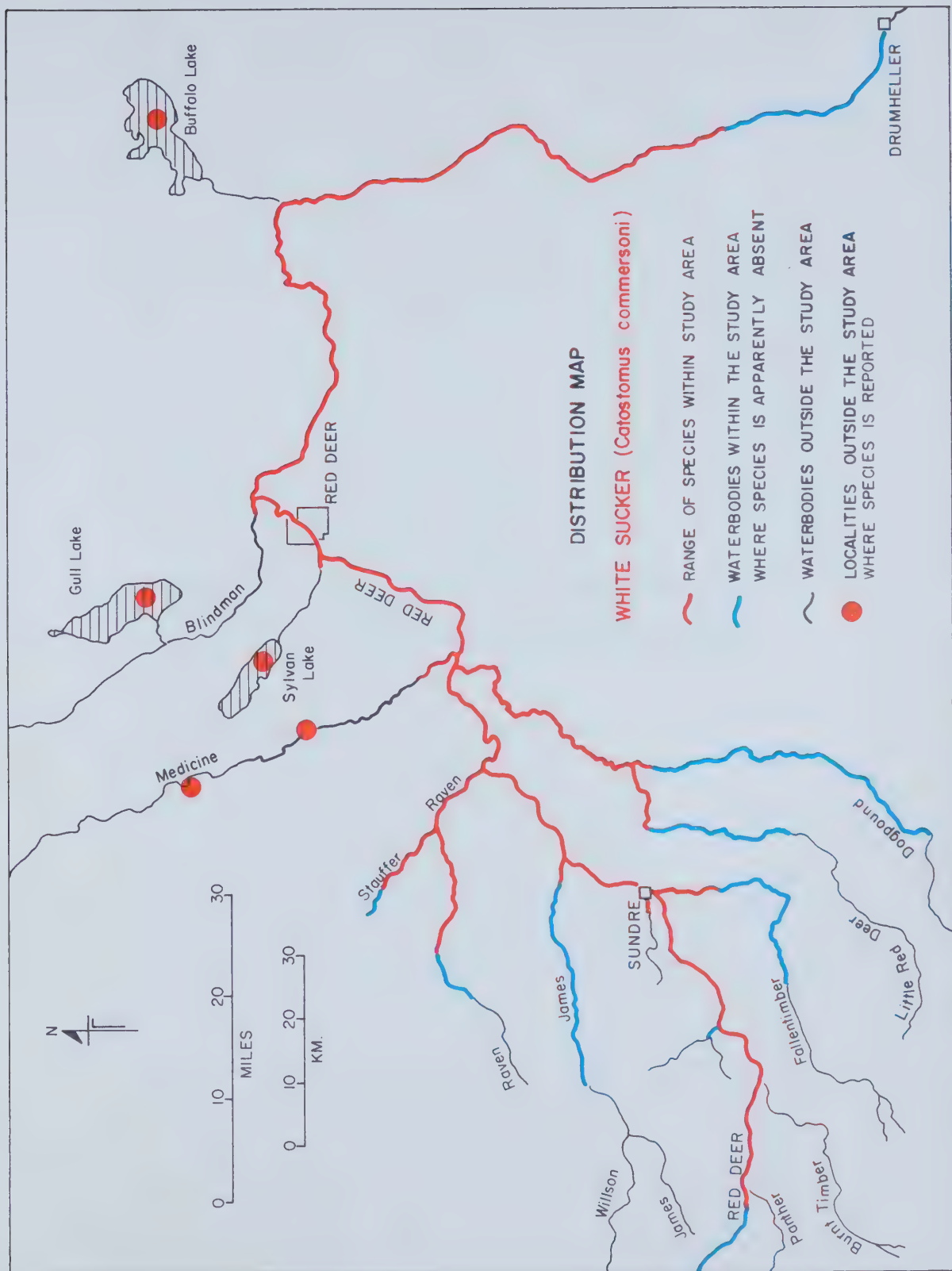


Figure 23. Distribution of the longnose
sucker within the Study Area.

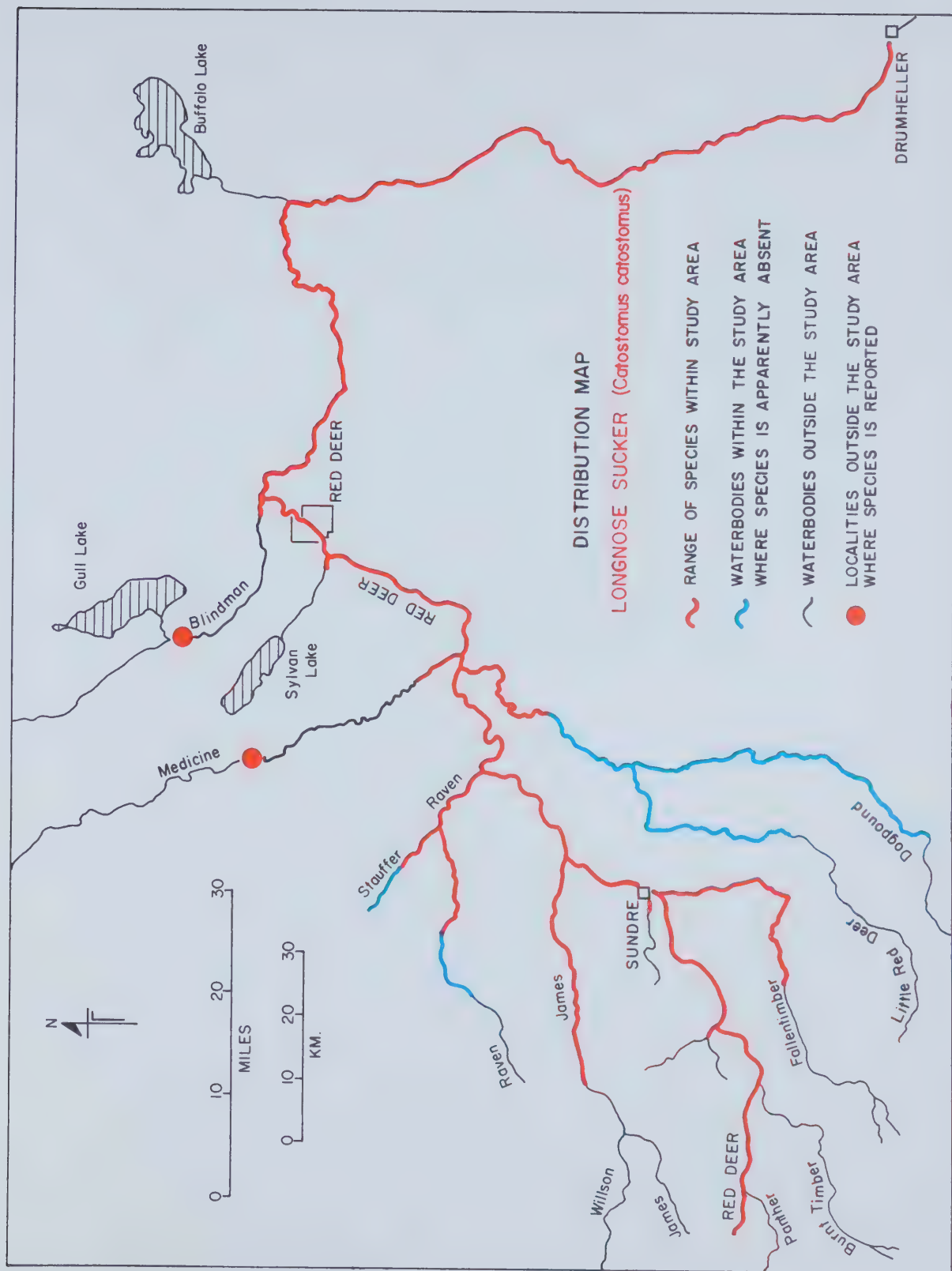
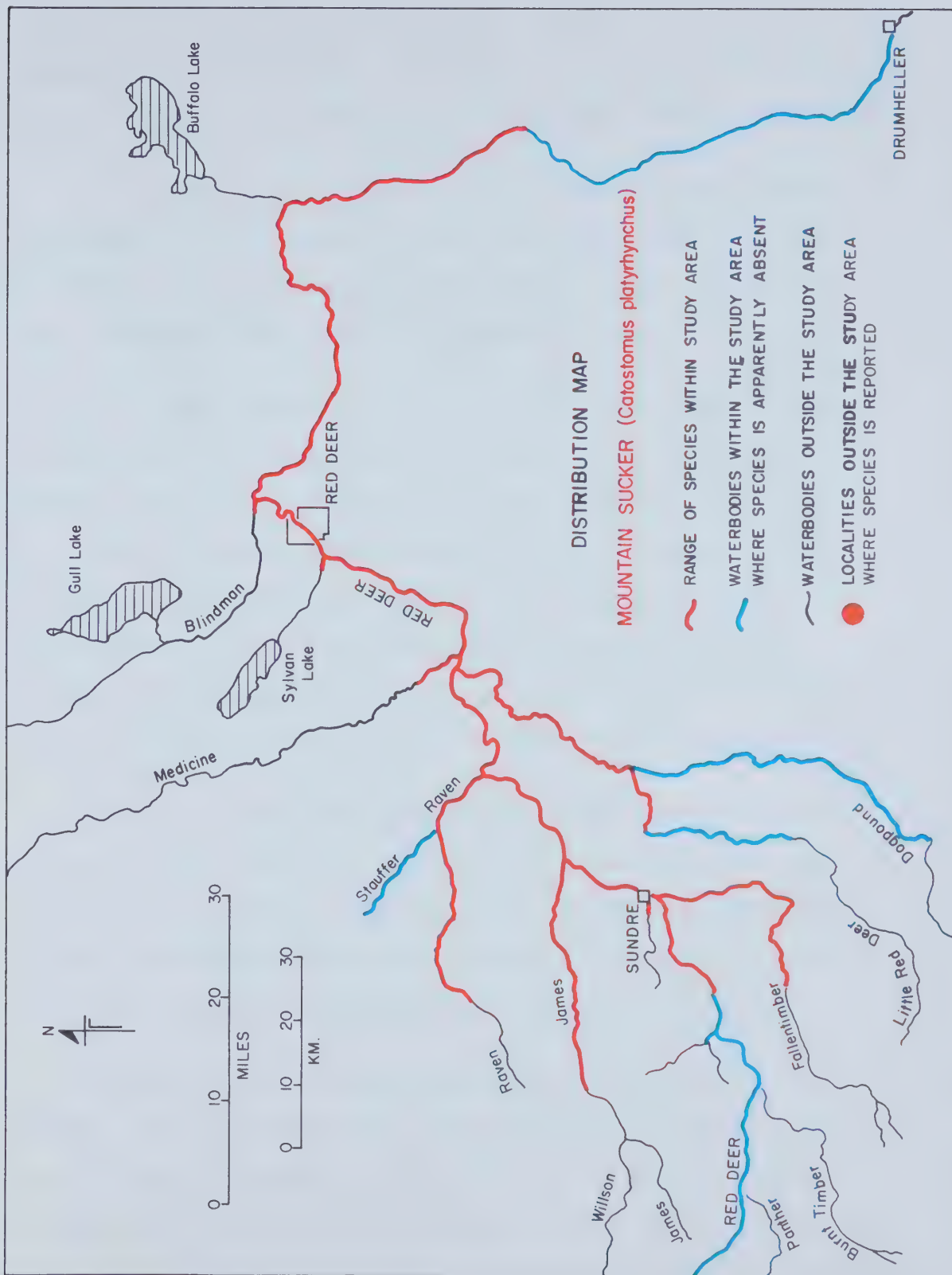


Figure 24. Distribution of the mountain
sucker within the Study Area.



comparable to that of many warm water sports fish, from the lower reaches of the Raven River downstream (Figure 25).

All suckers are spring spawners. Although the spawning requirements of the species differ somewhat, they are not especially rigid and young-of-the-year of each species were found throughout the ranges of the adult fish.

The length frequencies of the three most abundant species are presented in Figures 26 , 27 and 28 . Growth data are given in Table 7 and growth curves are compared in Figure 29 . The mountain sucker is the slowest-growing, shortest-lived, and smallest of the three species. The growth and age distributions of the white and longnose suckers are very similar. The youngest mature fish in the samples of mountain, longnose and white suckers were 5, 6 and 7 years respectively.

Spawning in the Study Area took place before the field portion of this study was initiated so there is no direct evidence of movements. However, major migrations of suckers to and from spawning areas are typical of the species along with other movements to feeding and overwintering areas.

Suckers are not normally considered to be sports fish. However, they can easily be taken with baited hooks and do provide some recreation, especially for children. White suckers were frequently observed in the possession of anglers, often being cut up and used as bait for other species. Though not themselves sports fish, suckers can influence the sports

Figure 25. Distribution of the shorthead
redhorse sucker within the
Study Area.

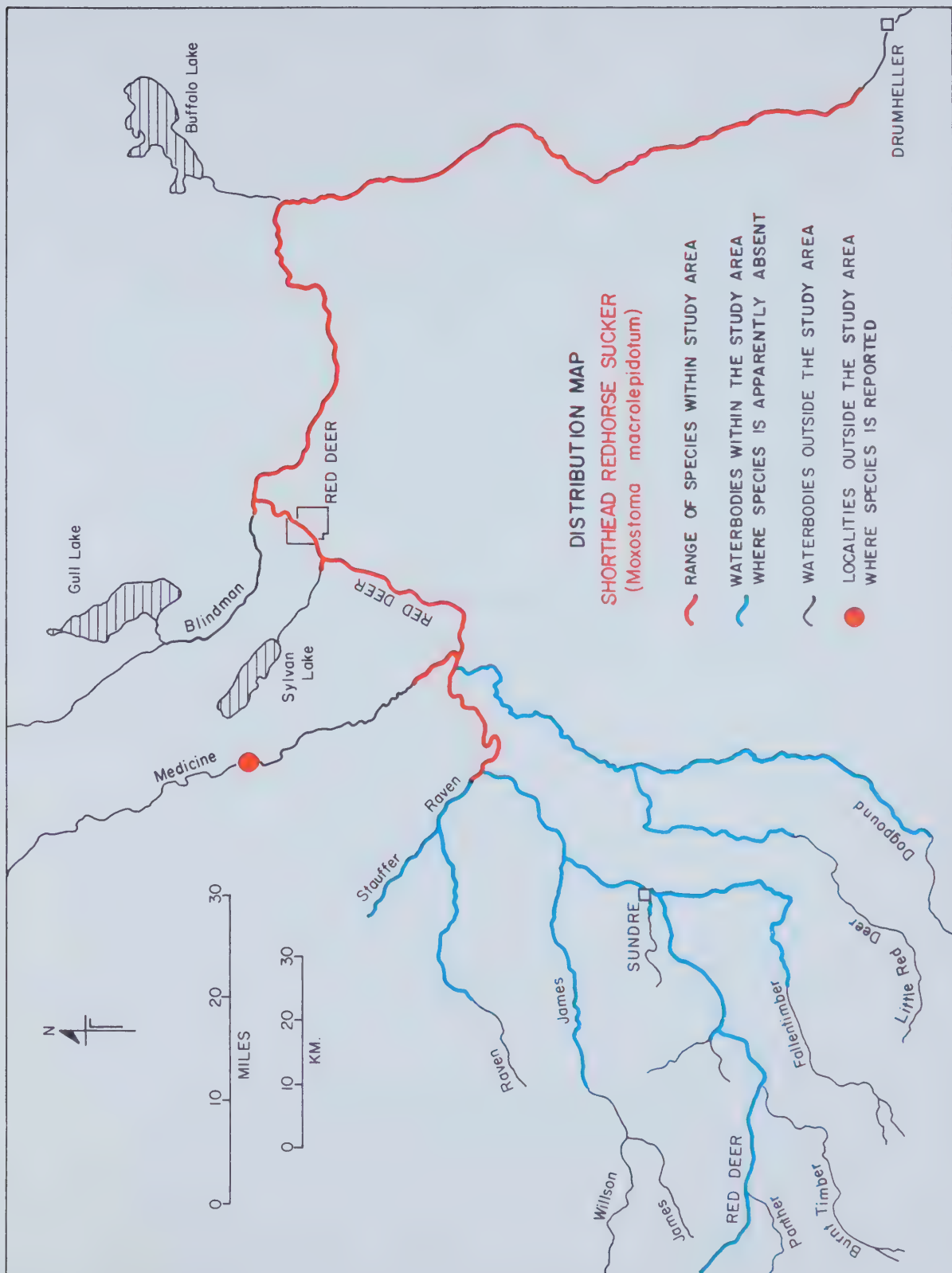


Figure 26. Length frequency of the white suckers captured during the study.

WHITE SUCKER

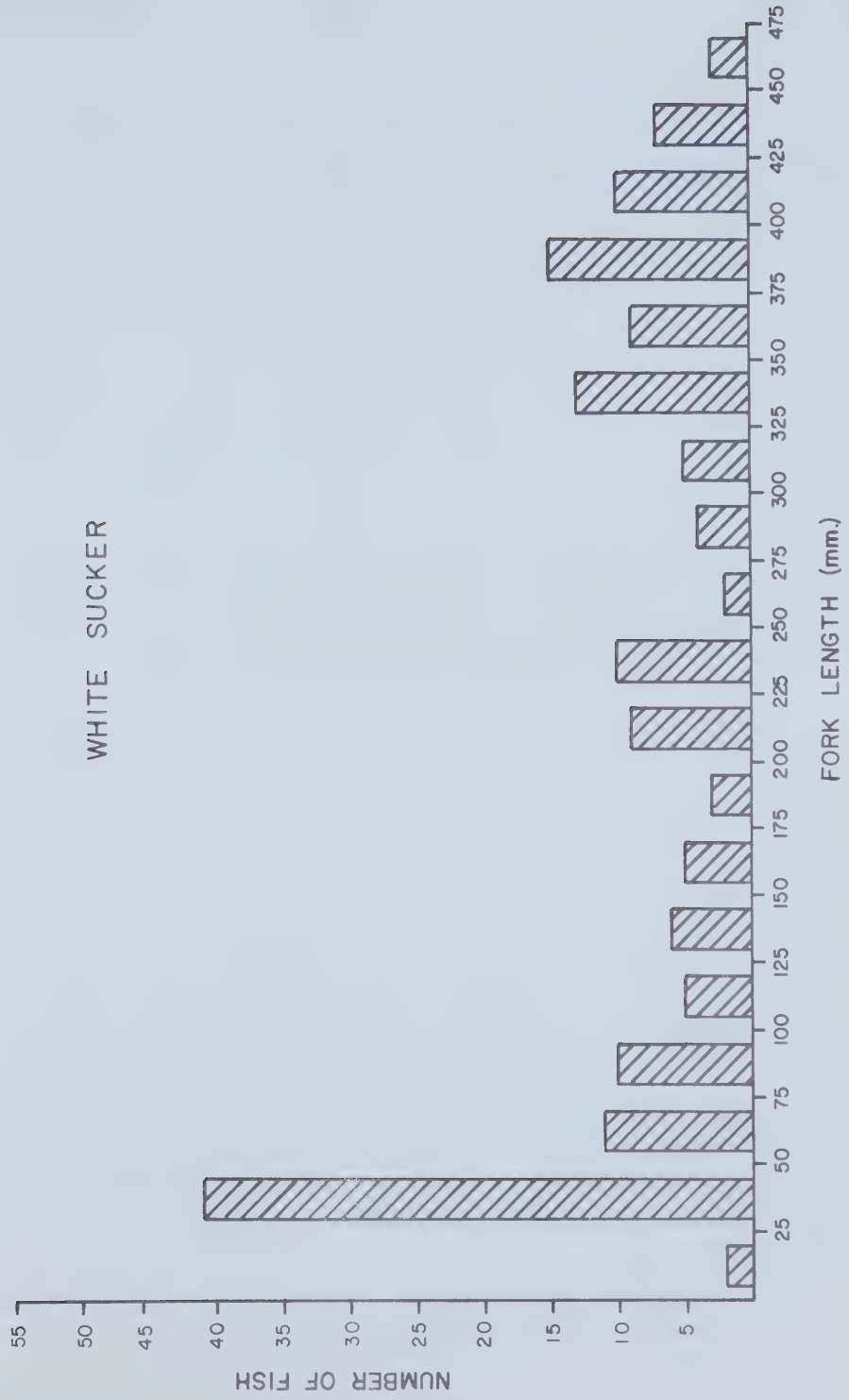


Figure 27. Length frequency of the longnose
suckers captured during the study.

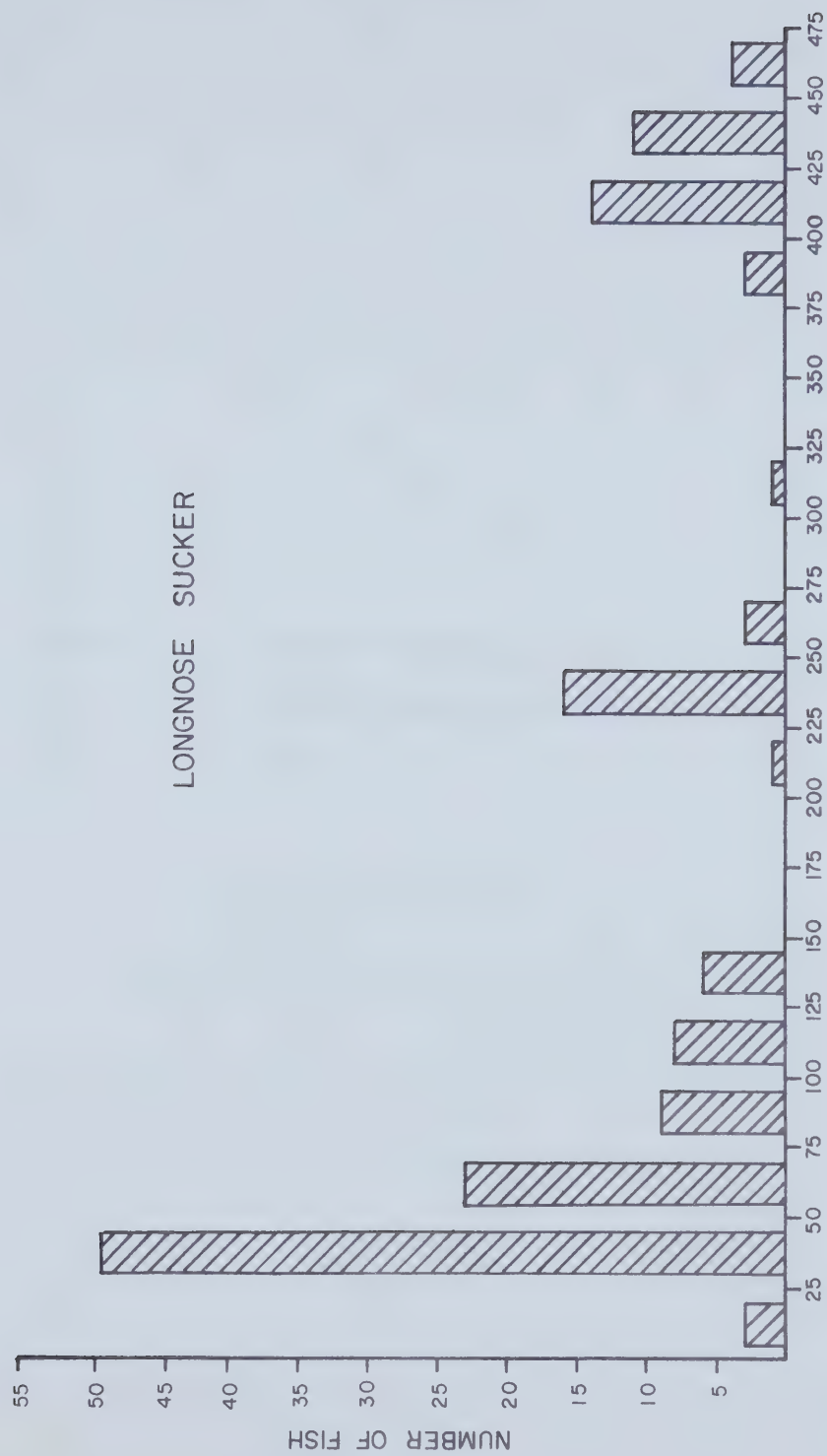


Figure 28. Length frequency of the mountain suckers captured during the study.

MOUNTAIN SUCKER

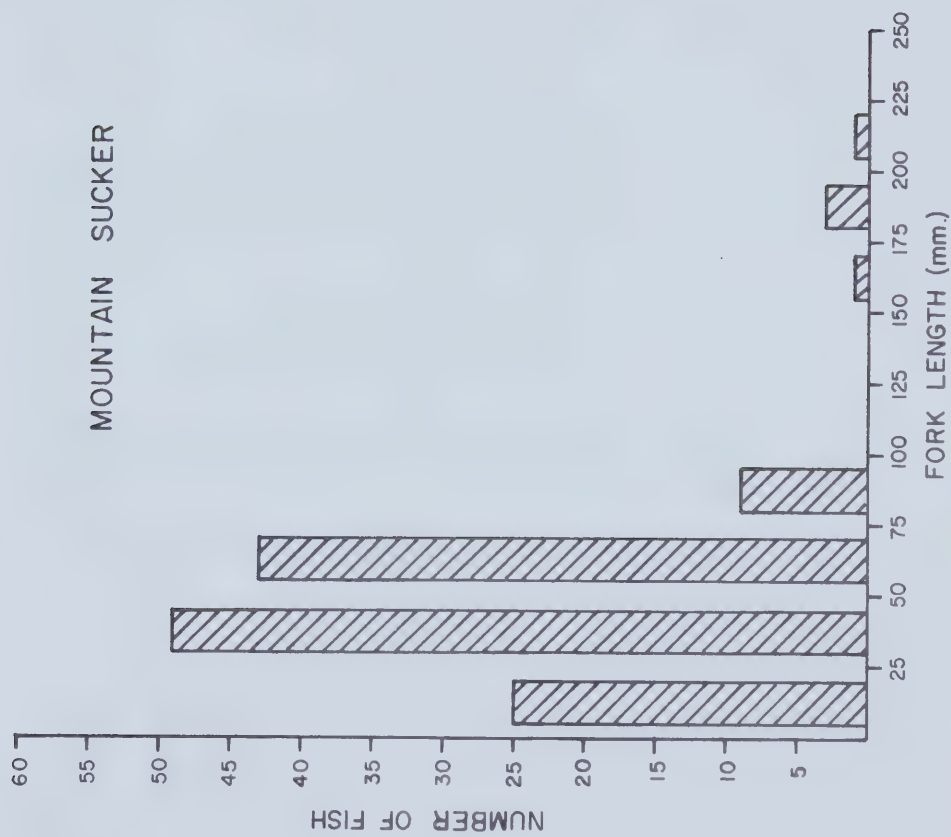
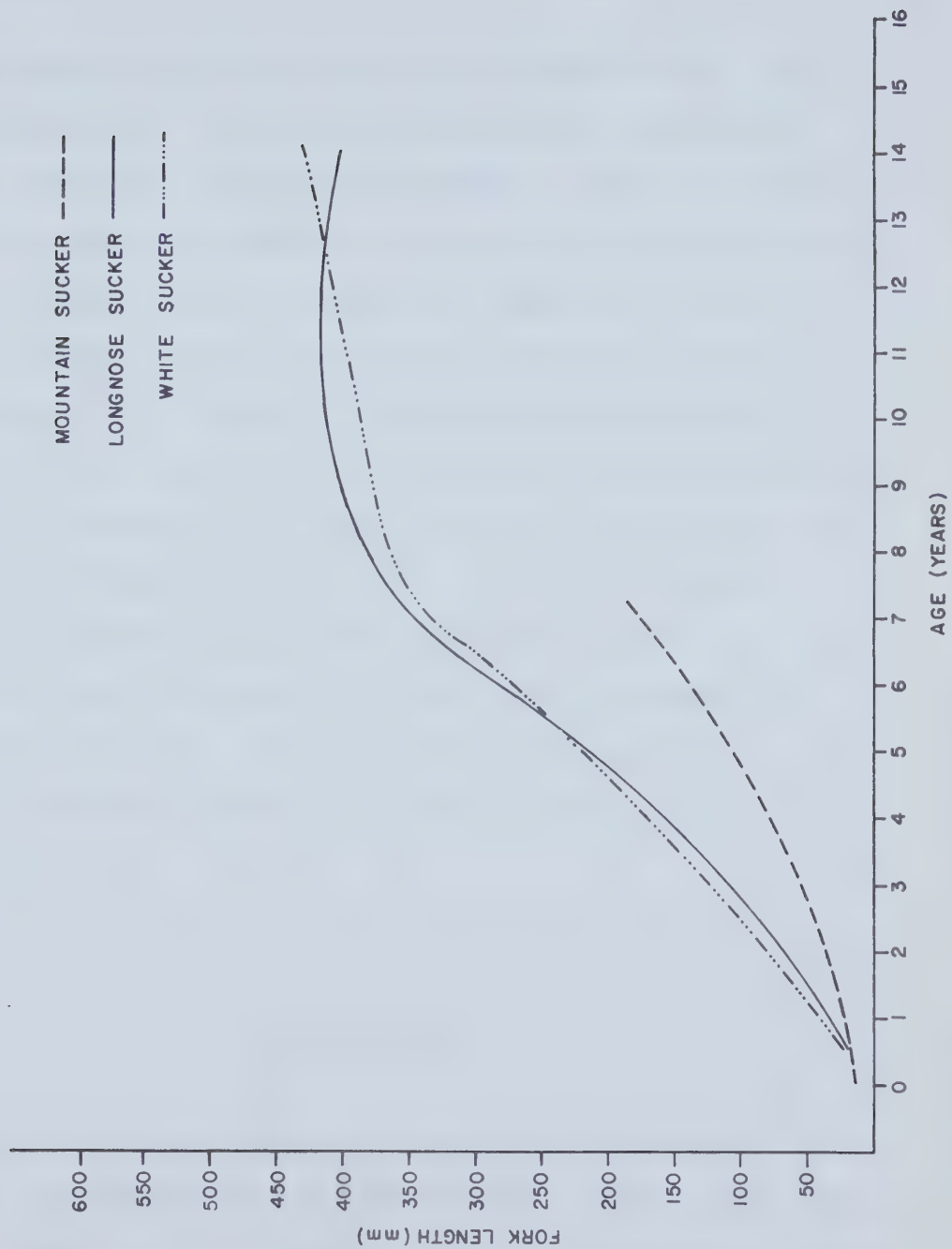


Table 7. Otolith age-fork length relationships of three species of suckers examined during studies of proposed red Deer River Damsites, 1974. S.D. is standard deviation.

Age	LONGNOSE SUCKER				WHITE SUCKER				MOUNTAIN SUCKER			
	N	Mean	S.D.	Fork Length (mm) Range	N	Mean	S.D.	Fork Length (mm) Range	N	Mean	S.D.	Fork Length (mm) Range
1	21	44	9.0	28-55	19	38	4.8	30-47	6	28	4.4	21-35
2	18	74	16.6	56-131	5	73	10.0	59-84	7	45	3.8	37-50
3	9	112	13.3	88-133	11	106	26.2	64-151	16	60	6.0	47-70
4	1	130	-	-	17	213	23.5	157-244	5	85	10.9	64-93
5	2	248	7.5	241-256	3	219	25.8	183-243				
6	1	308	-	-	1	242	-	-	3	149	2.6	145-151
7					6	340	27.1	300-385	2	169	11.5	158-181
8	1	382	-	-	3	357	6.2	350-365				
9	2	406	3.5	403-410								
10	1	413	-	-	3	402	13.1	390-420				
11	1	380	-	-	1	395	-	-				
12												
13					1	398	-	-				
14					1	431	-	-				
Totals	57				71				39			

Figure 29. Comparison of the age and growth of the white, longnose and mountain suckers captured during the study.



fishery in an area. Nelson (1965) suggests that one of the reasons for the reduction in Dolly Varden populations in the Kananaskis River system is competition from longnose and white suckers.

Both white and longnose suckers do well in lake and reservoir habitats. After white suckers were introduced into the Kananaskis Reservoir (probably as bait fish) they greatly increased in numbers to become one of the dominant species (Nelson, 1965). At the same time, the native longnose suckers declined for unknown reasons. In Willow Creek Reservoir in Montana, longnose and white suckers together were the most numerous large species, approximately 10 times as abundant as rainbow, brown and brook trout and mountain whitefish combined (Posewitz, 1962). Mountain suckers are adapted to fast flowing water, rarely occur in lakes (Scott and Crossman, 1973) and would presumably not do well in reservoirs. The shorthead redhorse does occur in lakes and would presumably do well in warm water reservoirs.

Forage Species

There are three species of small fish which are extremely abundant within the Study Area: the longnose dace, the lake chub and the troutperch. With the exception of the

headwaters of the Red Deer River and its mountain tributaries, each of these species was abundant wherever samples were taken (Figures 30 through 32).

The length frequencies of the three species are presented in Figures 33 and 34. As indicated, each of the species is small, no individuals exceeding 100 mm. No ages have been determined for these species.

Each of the three species is a late spring or summer spawner. Green female trout-perch, 85 mm in length, still unspawned with eggs 1.2 mm in diameter, were captured as late as June 27, 1974 in the Little Red Deer River. On June 19, 1974 a mature, unspawned female longnose dace, 82 mm, was captured in the James River. On the same day an unspawned female lake chub, 85 mm, was taken in a small, unnamed tributary of the Red Deer River west of Bowden. These data suggest that spawning in the three species does not begin until at least late June, probably dependent on water temperatures.

While the three species are obviously not sports fish (though one angler interviewed during the creel census did catch and retain a longnose dace) they are all considered to be extremely important forage fish (Scott and Crossman, 1973) and any reduction in their numbers might affect populations of sports fishes which prey on them.

Figure 30. Distribution of the longnose
dace within the Study Area.

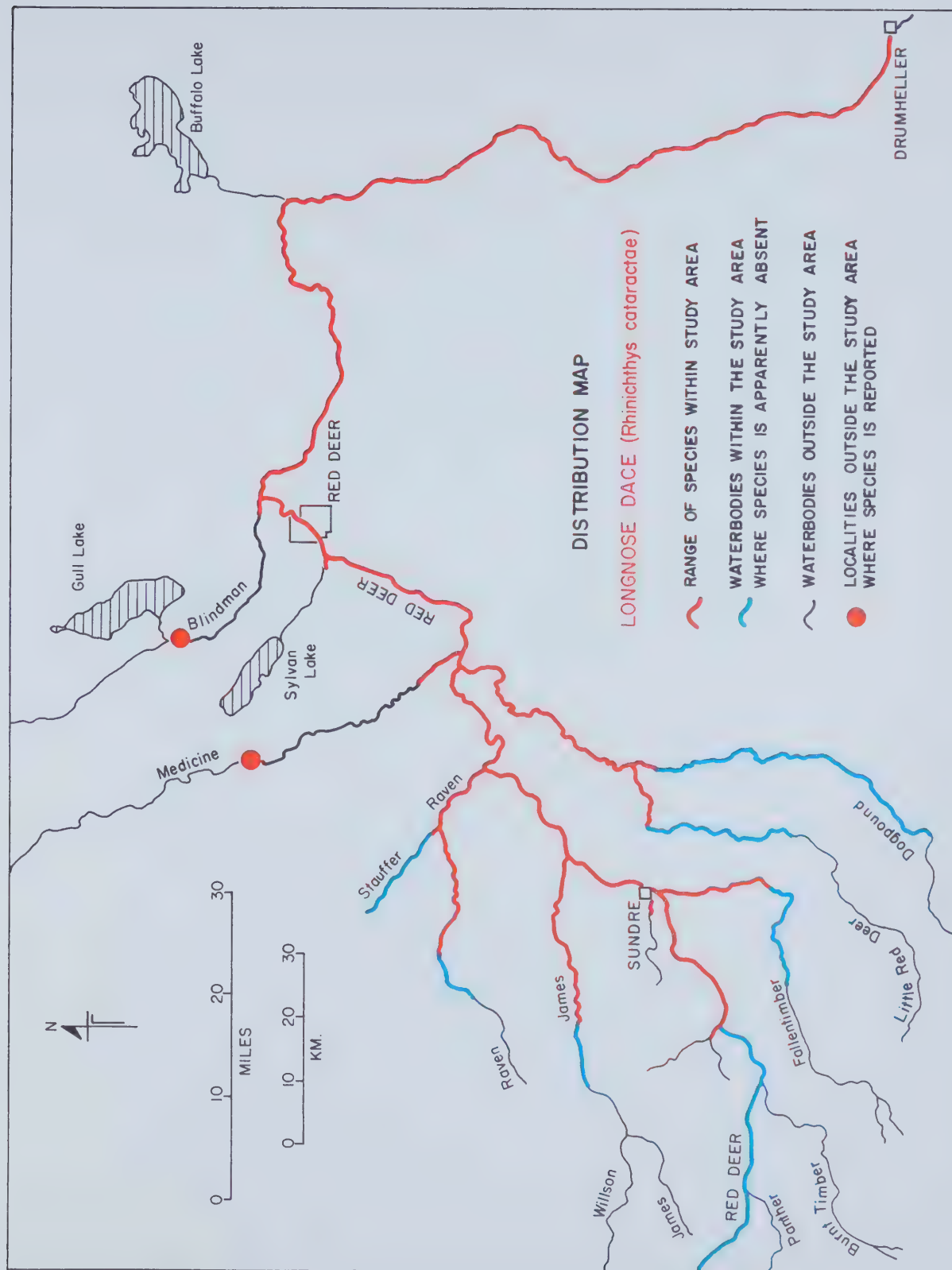


Figure 31. Distribution of the lake chub
within the Study Area.

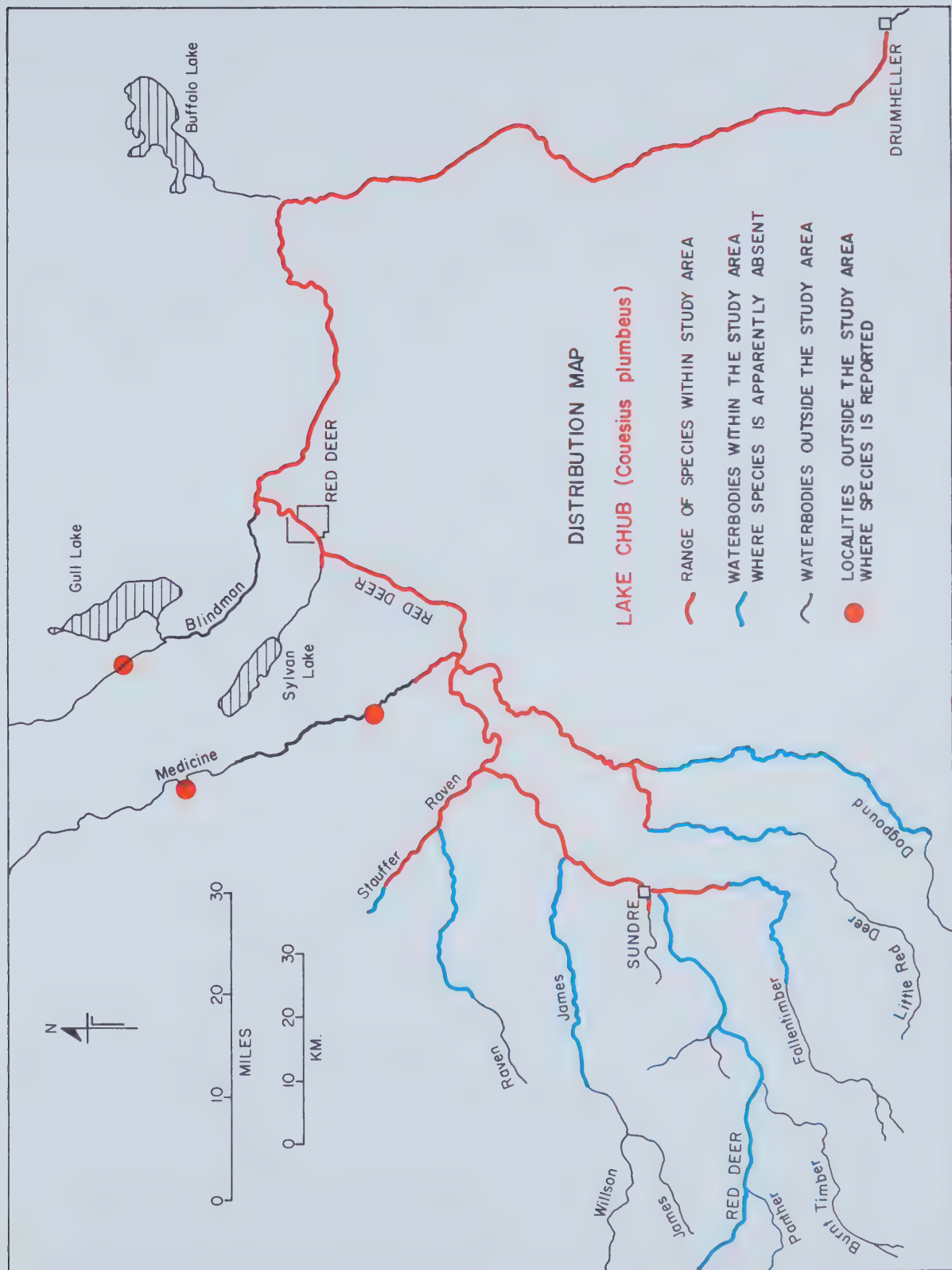


Figure 32. Distribution of trout-perch
within the Study Area.

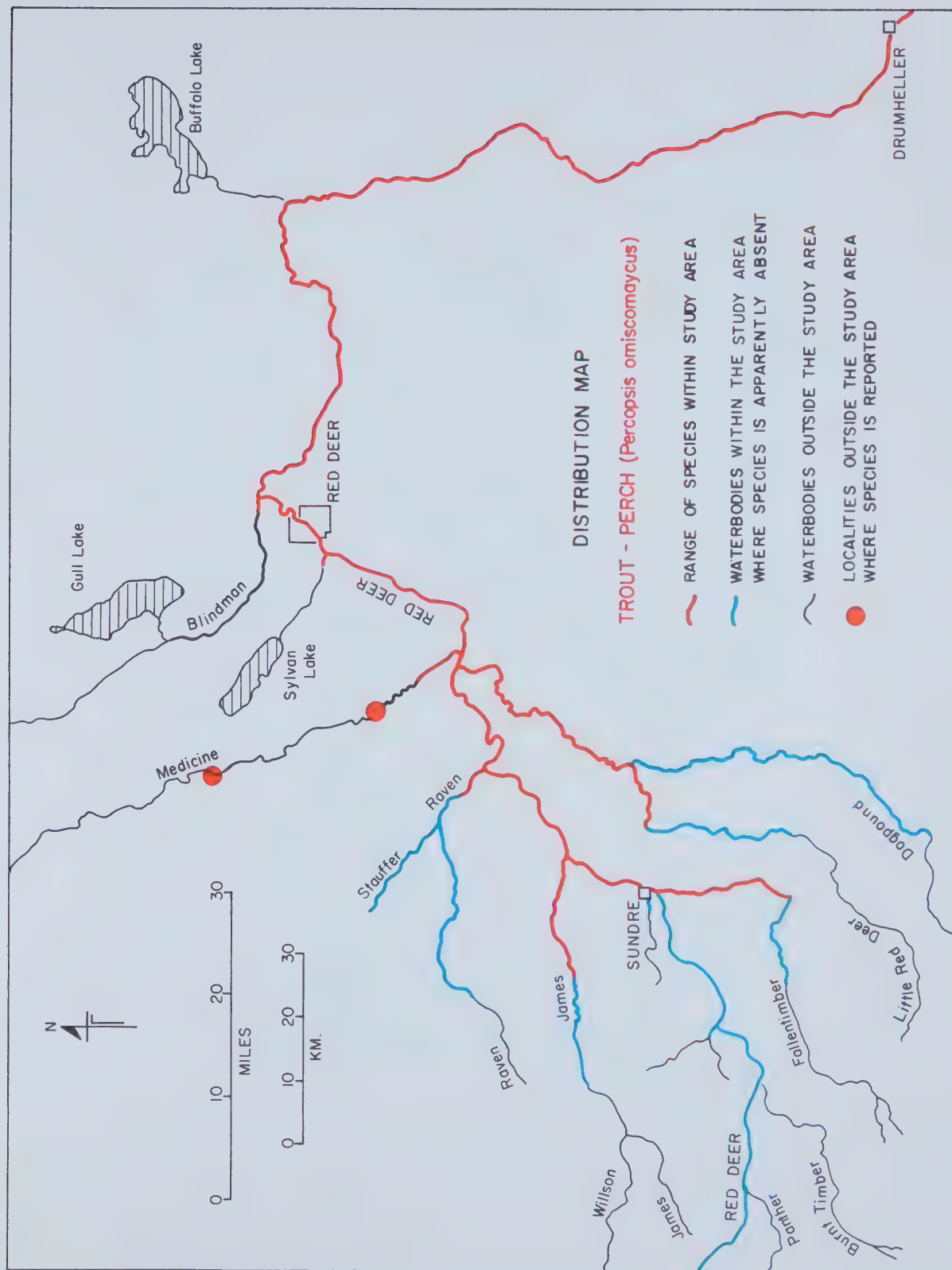


Figure 33. Length frequency of the longnose
dace captured during the study.

LONGNOSE DACE

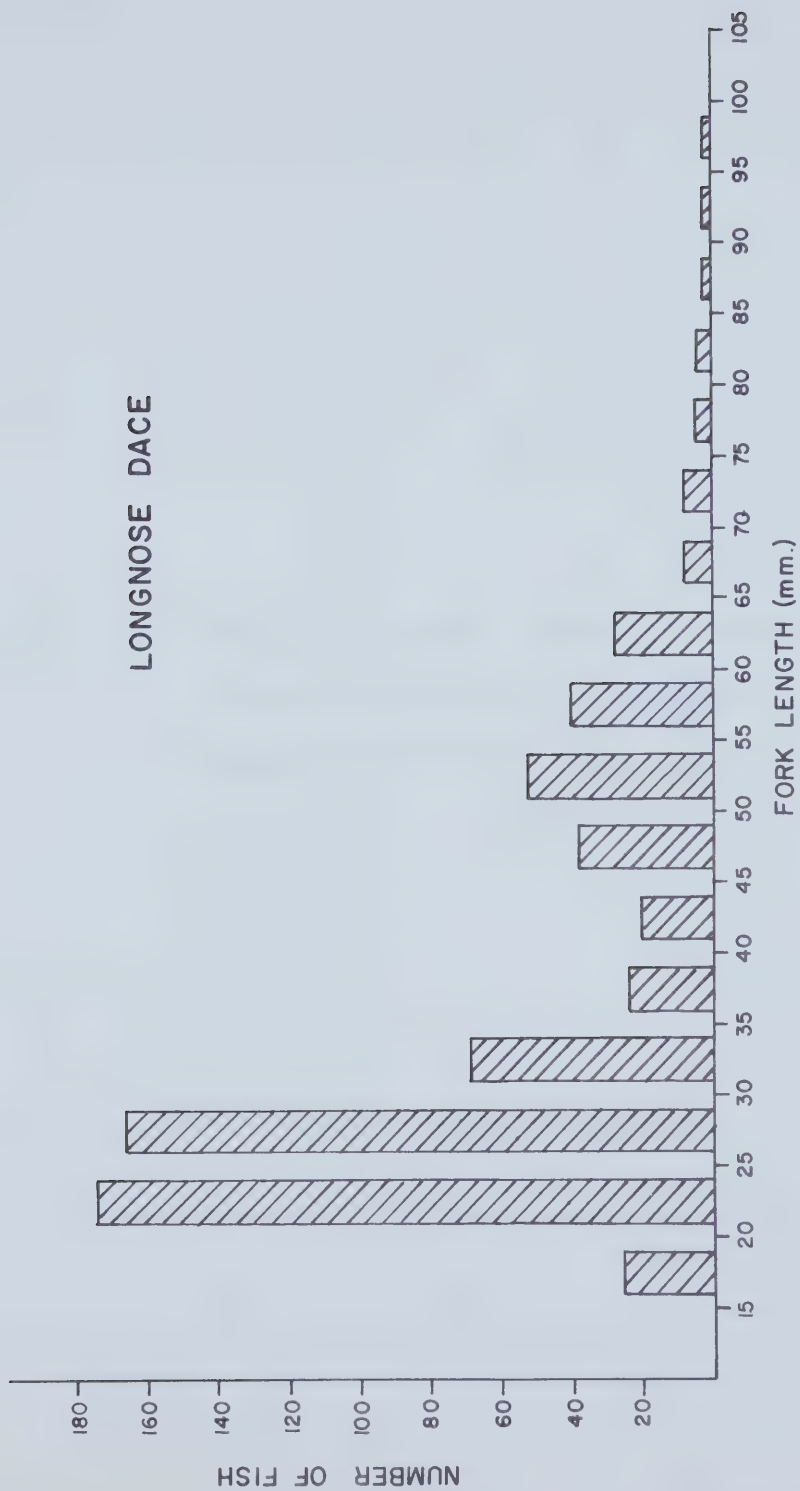
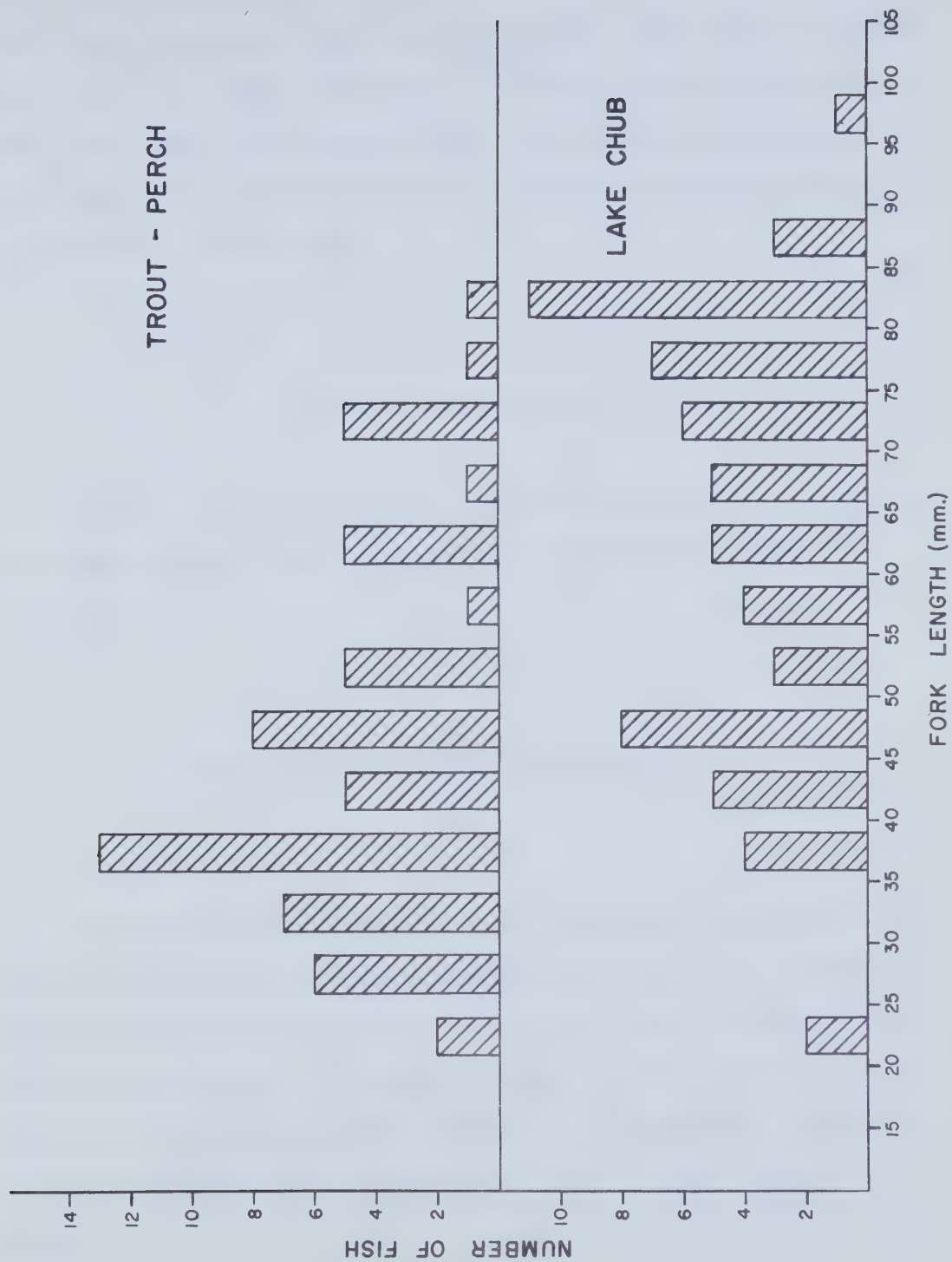


Figure 34. Comparison of the length frequency of the lake chub and trout-perch captured during the study.



The wide distribution of the three species and the fact that each occurs in lakes, small streams and rivers, suggest that they are highly adaptable. Nelson (1965) noted that both lake chub and longnose dace have become established in reservoirs in the Kananaskis system after having been accidentally introduced.

Miscellaneous Species

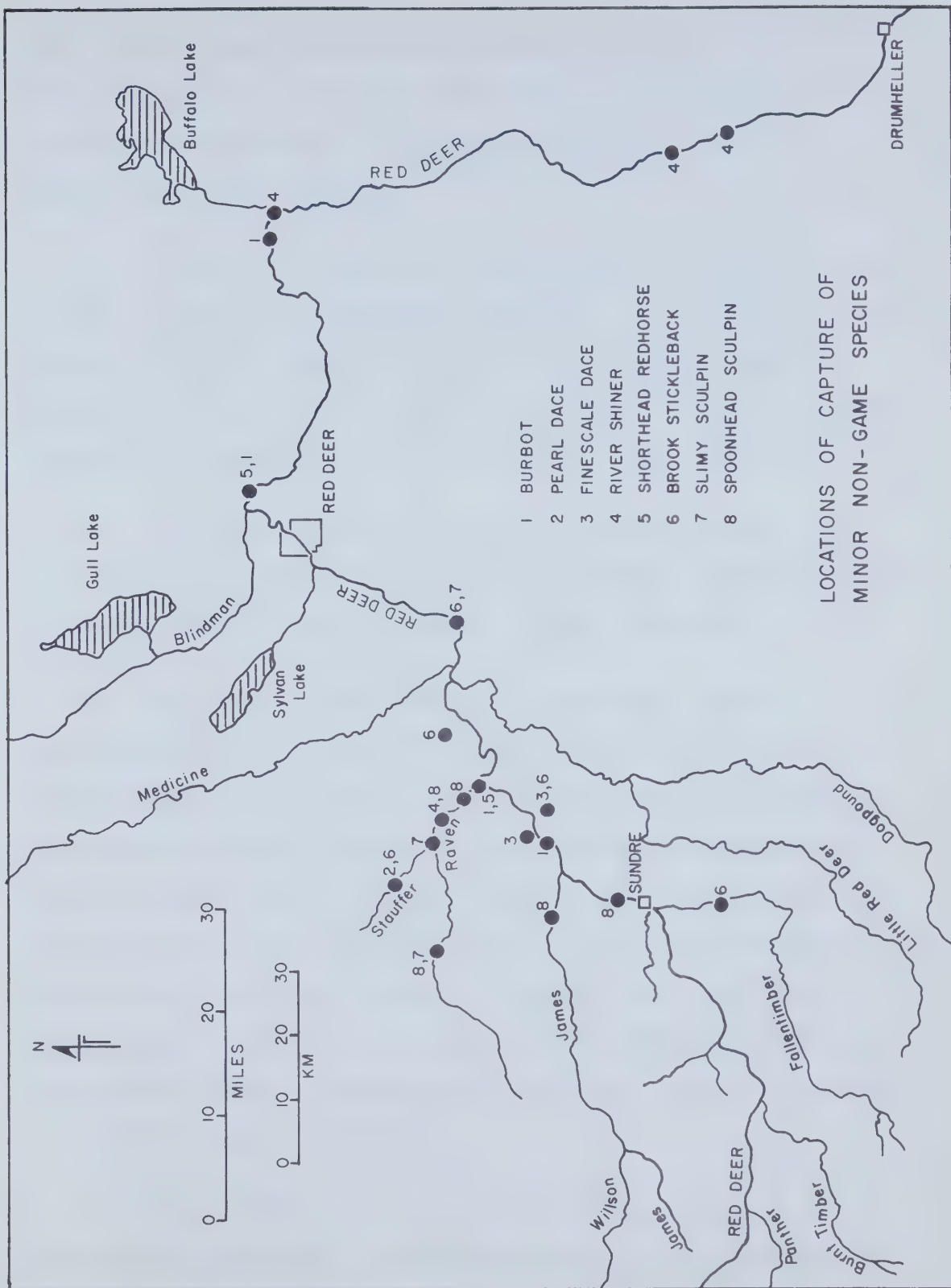
Figure 35 indicates the capture localities for 8 minor, non-game species taken during the course of fisheries studies.

COLD WATER AND WARM WATER HABITATS

One of the objectives of this study was to define those areas of the Red Deer River basin which could be regarded as cold water fish habitat and those which were predominantly warm water habitat. The data on species distributions can be used to accomplish this. Most of the commoner species in the drainage can be assigned to one or four distinct groups:

- 1) A group including the brown trout, brook trout,

Figure 35. Map showing the locations of capture of minor non-game species taken during the study.



LOCATIONS OF CAPTURE OF
MINOR NON-GAME SPECIES

Dolly Varden and rainbow trout which is largely restricted to the upper portion of the Red Deer River above Damsite 7 and to suitable localities in tributary streams. These are typical cold water species.

2) A group including the northern pike, walleye, sauger, mooneye, goldeye and shorthead redhorse, all typical warmwater species, which are characteristic of the warmer, slower portions of the Red Deer River and its tributaries and do not penetrate upstream more than a few miles above Damsite 6.

3) A group including white and longnose suckers, lake chub, longnose dace and trout-perch which are found throughout the study area in both cold and warm water habitats.

4) One species, the mountain whitefish, appears to be restricted to cold water habitats for spawning but utilizes warm water habitats often far downstream during its juvenile life history stages. This pattern of distribution allows this species to exploit the food and other resources of a wider area than would be possible were they restricted to a narrower range of habitat. However, the fact that a large proportion of the juveniles are located downstream of the spawning grounds necessitates an often lengthy migration at the time these fish mature.

Obviously there is a great deal of variation in temperature preference even within groups. For example, though both are grouped as cold water species, optimal

temperatures for the growth of brown trout are higher than those of brook trout and therefore the former tend to occupy warmer waters than the latter (*e.g.* in Stauffer Creek; Shirvell, 1972). For this reason, no very exact distinction of typical cold water and warm water fish habitats is possible. However, if the distinction is based largely on the distribution of species in groups 1 and 2, a definite pattern emerges. The cold water fish predominate in the Red Deer River and its tributaries upstream of Damsite 6 and in the higher altitude upper courses of the Little Red Deer River and Dogpound Creek (Figure 36).

Downstream of Damsite 6, warm water species replace cold water ones in the Red Deer River itself and its tributaries (Figure 37), except, as previously indicated, in the upper portions of the Little Red Deer River and Dogpound Creek. In the Red Deer River, warm water fish extend upstream a few miles beyond Damsite 7. They also occupy the lower reaches of the Raven River and Stauffer Creek. These are the major areas of overlap with cold water species. It can be seen that the typical cold water and warm water habitats correspond very closely to geographic Regions I and II and that the proposed reservoirs at Sites 6 and 7 are in the zone of overlap.

A comparison of catch per unit effort statistics for Regions I and II (Table 8) indicates that the latter is much more productive than the former. The best comparison is

Figure 36. Distribution of the cold water species of fish within the Study Area.

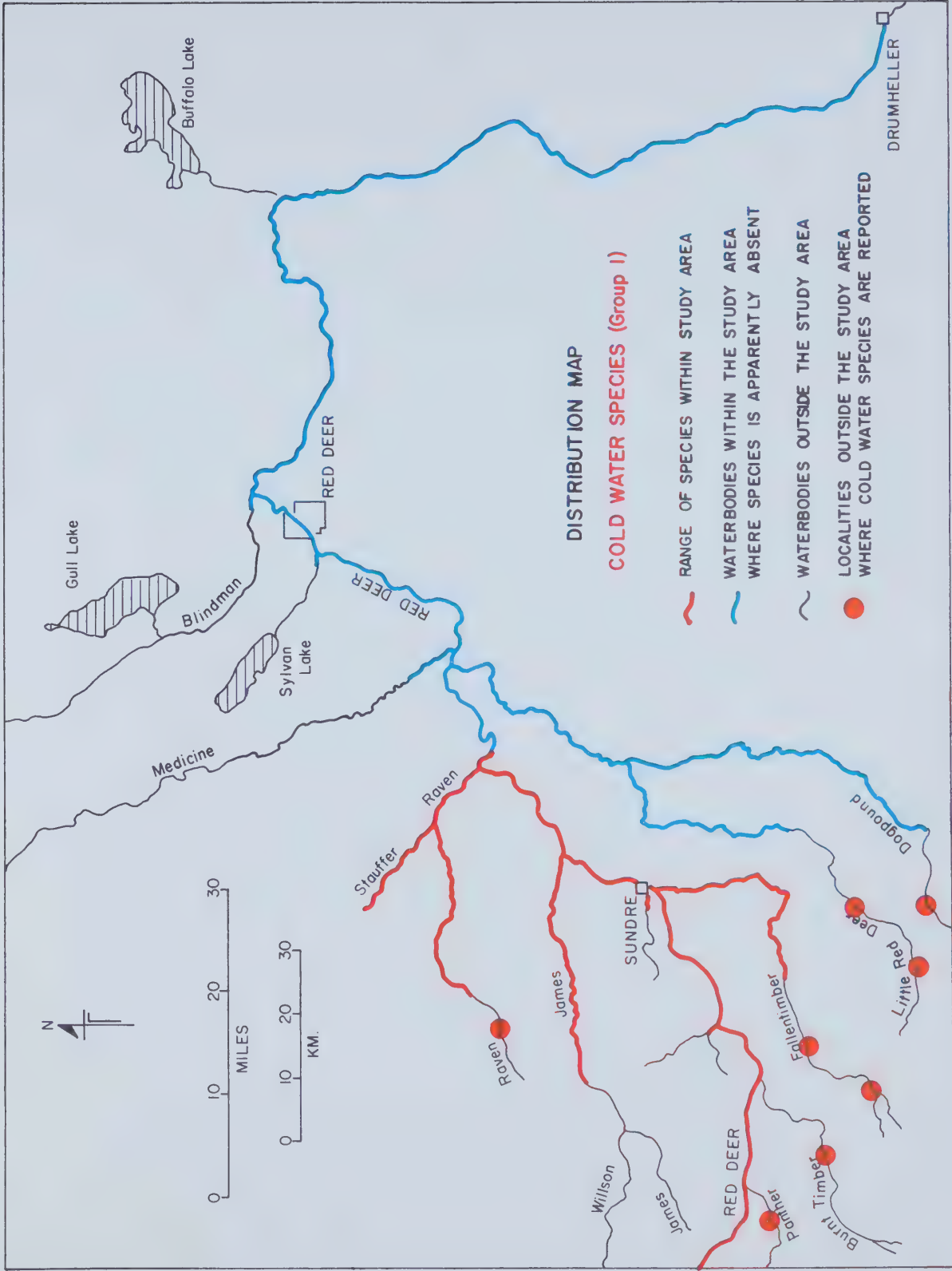


Figure 37. Distribution of the warm water species of fish within the Study Area.

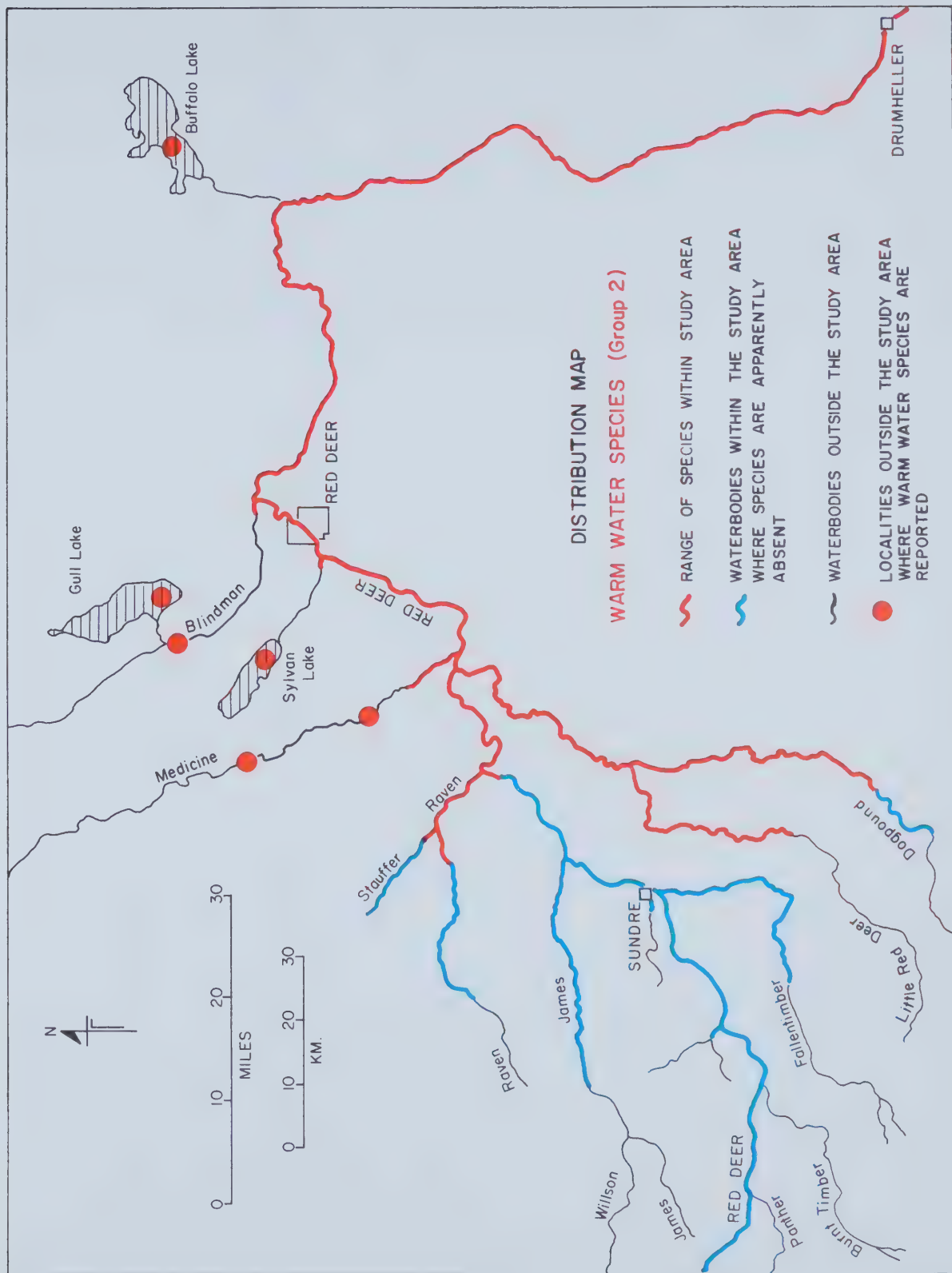


Table 8. Catch per unit effort statistics for mainstem of Red Deer River upstream (Region I) and downstream (Region II) of Damsite 6 and for Raven River. Data from Red Deer River Damsite Studies, 1974.

Method	REGION I			RAVEN RIVER			REGION II		
	Total Effort	Total Catch	Catch per Unit Effort	Total Effort	Total Catch	Catch per Unit Effort	Total Effort	Total Catch	Catch per Unit Effort
20' minnow seine	2390 m	1922	7.5	175 m	372	21.2	1155 m	7752	67.1
2" to 3" gillnet	209 hr	223	0.6	138 hr	151	1.1	27 hr	33	1.2
electro-shocker	19.4 min	140	2.6	34.3 min	62	1.8	6 min	9	1.6
angling	7.7 hr	7	0.9	4 hr	8	2.0	2.0 hr	5	2.5

with seine catches where there was substantial effort in both regions. The catch in Region II, the warm water habitat, was nine times greater than that in Region I, the cold water habitat. Catches in the Raven River were intermediate. The apparently higher levels of productivity in Region II and the Raven River in comparison with Region I are probably related in part to:

- a) higher water temperatures
- b) higher nutrient loadings resulting from the proportionately greater areas of productive farmland included within the Region II and Raven River drainages.

UTILIZATION OF THE FISHERIES RESOURCE

Creel Census

During the course of the fisheries surveys, Aquatic Environments interviewed all anglers that were encountered. Table 5 is a summary of the information obtained. Forty-seven groups totalling 120 anglers were contacted. Most of the anglers interviewed were on the Red Deer River between Sundre and Innisfail (48%) or on the Raven River or Stauffer Creek (41%). These are the areas which will be most affected by the proposed dams. Few anglers were encountered during field surveys in other areas.

Anglers were concentrated around provincial campgrounds or other traditional camping sites. All of the anglers were Alberta residents and 75% were from the Red Deer region. All others, except two, were from Calgary. The anglers interviewed travelled an average one-way distance of 44 miles to reach fishing areas. The average angler caught 1.8 fish per hour and had 1.4 fish in possession when interviewed.

Species composition of anglers' catches is further summarized in Table 9. The mountain whitefish was the sports species most often in possession of anglers accounting for 32% of the catch followed by brown trout (18%) and brook trout (12%). Among warm water sports species, goldeye were most abundant (13%). Other sports species (Dolly Varden, northern pike and walleye) were only a minor constituent. Suckers, mostly whites, constituted a surprising 20% of the total angler catch.

The majority of the people interviewed seemed to be very casual anglers, more interested in just getting out-of-doors and relaxing than fishing. They were ill-informed on what species of fish might be present and what the best method might be for catching them. The exceptions often were local residents some of whom have lived and fished in the vicinity for up to 42 years. These anglers were generally well informed about the availability of various species at various times of the year and were quite successful at angling. In addition, they provided information about spawning times and

TABLE 9. Species composition of fish taken by anglers interviewed during Fisheries Study, 1974.

Species	Number Caught	Percent of Total
Dolly Varden	2	1
Brook Trout	20	12
Brown Trout	31	18
Mountain Whitefish	55	32
Goldeye	23	13
Northern Pike	4	2
Walleye	2	1
Suckers	34	20
Other	2	1
Total	173	100

locations that proved useful to the fisheries field crew.

ECONOMIC VALUE OF THE RED DEER RIVER SPORT FISHERY

The sport fishery on the Red Deer River is of considerable economic value to the region and to the province. It is difficult to assess the actual dollar value of the Red Deer River sport fishery because most available data is tabulated on a regional or province-wide basis. The time-lag between the collection and the publication of statistical data and the rapid changes in the economic structure of the province of Alberta coupled with economic variables such as inflation compound the problem even more.

R.J. Miller (1971) in "Alberta's Hunting and Fishing Resources: an Economic Evaluation", has compiled selected hunting and angling statistics for the years 1968 and 1969. These data were obtained by the use of questionnaires and from Fish and Wildlife Division records. From Miller's tables it is possible to extract the data which pertains to the Red Deer River drainage. Miller estimates the provincial total number of angler days (angler day--all or part of each day angled by one angler) to be 1,958,645 and 2,269,149 for the years 1968 and 1969 respectively. Miller estimates approximately 227,644 angler days of sports

fishery activity occurred in the Red Deer River basin during 1968 and approximately 272,297 angler days during 1969.

Miller has also calculated the resident angler's seasonal expenditures for such things as travel costs, equipment purchases, licenses, etc. In 1968 and 1969 the average angler spent approximately \$135 per season. Province-wide the total expenditure for angling was approximately 16.9 million and 18.4 million dollars for the years of 1968 and 1969 respectively. Since the Red Deer River drainage accounts for about 12% of the angler days for the province, it can be assumed that the value of the sports fishery in the Red Deer River was in the neighbourhood of 1.9 to 2.1 million dollars during the years of 1968 and 1969.

By using the number of angling licenses sold over a period of years as an index, it is possible to project the growth of sports fishing activity in Alberta. License sales do not however take into account persons under 16 or over 65 years of age because they are not required to buy licenses.

Table 10 shows the total number of angling licenses sold in Alberta and the cumulative percent increase in sales each year. Since 1968 and 1969 respectively, the years used in Miller's evaluation, there has been a 30 and 20 percent increase in the number of anglers buying licenses. Assuming that there has been a similar increase in angling activity in the Red Deer drainage, then the value of the sports fishery

Table 10. Number of angling licenses sold in Alberta.¹

91

Year	Number	Cummulative % Increase
1965-1966	122,537	
1966-1967	133,092	8
1967-1968	136,693	11.5
1968-1969	140,874	14.9
1969-1970	152,978	24.8
1970-1971	151,205	23.3
1971-1972	162,480	32.5
1972-1973	175,773	43.4

¹Annual reports, Department of Lands and Forests, Fish and Wildlife Division, Queen's Printer, Edmonton.

in the Red Deer River is approximately 2.5 million dollars in 1974.

Again, using angling license sales as an index, with an average annual increase of about 6%, it is possible to predict an approximate 60% increase in angling activity every 10 years (see Table 11). To relate this to the Red Deer River specifically, however, is very difficult. Factors such as increased accessibility, that is, road development, increased camping and picnic facilities, trailer camps, provincial parks, etc., along with increased publicity, could dramatically increase the popularity of the Red Deer River sport fishery. Conversely, too much development, publicity, and angling pressure could reduce angling productivity and cause the popularity of the area to be reduced greatly.

The figures showing the growth of the sports fishery in the Red Deer River are very optimistic and should be regarded as maximum values. Population projections obtained from the Red Deer Planning Commission and from Mr. Daraell Murri, Sociological Consultant (personal communications), indicate a much lower growth rate than the 6% per annum indicated by fishing license sales for the Red Deer basin as a whole. Populations in the rural areas are actually decreasing while the City of Red Deer is growing very slowly. The Red Deer Planning Commission puts the growth of the City of Red Deer at about 2% annually, while the figures of Gill and

Table 11. Projected growth of the sports fishery in the Red Deer River Drainage based upon an average increase of 6% per annum.

Year	Estimated Angler Days	Estimated Value of Sports Fishery
1969	272,297	\$2,100,000
1974	326,756	2,500,000
1984	522,809	4,000,000
1994	836,494	6,400,000
2004	1,338,390	10,240,000

Murri are even more conservative.

Even if the population growth remains low in the Red Deer Region, it is likely that more and more angling pressure will come from the larger metropolitan areas of Edmonton and Calgary in the future. At present 25% of the anglers interviewed during the course of the study were from the Calgary area.

POTENTIAL EFFECTS OF IMPOUNDMENT ON FISH POPULATIONS IN
THE RED DEER RIVER - CONSTRUCTION PHASE

There are several potentially serious sources of disturbance to fish populations associated with the construction of the dam. These include increased sediment loads, water pollution, disruption of migration patterns and the use of explosives.

Sediment Loads

There will undoubtedly be increases in suspended sediment loads, in turbidity and in stream bottom sedimentation downstream of the damsite during construction. The potential effects on the aquatic ecosystem include:

- 1) A reduction in primary productivity due to decreased light penetration, particularly that of the short wave lengths important to plant growth, thereby limiting populations of algae and other aquatic plants which form the basis of aquatic food chains (Ellis, 1936; Bullard, 1962; James, 1956; Cordone and Kelly, 1961).

- 2) A reduction in benthic invertebrate populations.

These are the insects and other organisms which inhabit stream bottoms and which are among the most important foods of fishes. Studies in other areas have shown that populations of various stream-dwelling fishes were reduced where benthic invertebrate populations were reduced by sedimentation (Cordone and Pennoyer, 1960; Peters, 1962; Pautzke, 1937).

3) Direct effects on fishes.

a) Studies have shown that the juveniles and adults of most species are tolerant of very high suspended sediment loads and even sensitive species were not killed until exposed to concentrations of 20,000 ppm or more for prolonged periods (Apman and Otis, 1965). This value far exceeds the maximum values recorded in the Red Deer River and those likely to occur as the result of construction activity. It is therefore unlikely that there will be any mortality to juvenile or adult fish directly attributable to increased suspended sediment loads.

b) Unlike juvenile and adult fish, the eggs and early life history stages of many species are extremely sensitive to the effects of sedimentation. Phillips (1971) has recently summarized these effects:

- sediment can cause mortality to eggs and alevins (recently hatched young still depend on the egg yolk for their nutrition) by filling the interstices in the gravel

and by reducing intragravel water flow thereby reducing the supply of oxygenated water to the egg and interfering with the removal of metabolites (carbon dioxide and ammonia).

- sediment forms a barrier to the emergence of the young from the gravel by blocking the spaces between stones through which the young move.

- survival after emergence is reduced due to loss of escape cover in the spaces between stones and reduction in the density of invertebrate food organisms.

The consequences of greatly increased suspended sediment loads are most likely to be serious if these occur during periods of the year when silt loads are naturally low, *e.g.* in the fall, winter and early spring. Aquatic organisms are adapted to the natural cycle of sedimentation. Fish spawning, for example, normally takes place when suspended sediment loads are small, in the early spring after ice melt but before the spring freshet, in mid-summer or in the fall when the threat of flooding is largely past.

As a general principle, conflict with the well-being of fish populations resulting from sedimentation will be least damaging if activities likely to result in heavy sediment loads are timed to occur when sediment loads are naturally high and periods not likely to be critical to spawning or incubation of eggs.

The foregoing is a general outline of the effects of increased suspended sediment loads on populations of aquatic organisms. Under some circumstances the effects can be serious, however, with particular reference to Damsites 6 and 7, increased sediment loads are unlikely to have any major effect on fish populations:

1) There is no evidence that spawning or rearing areas critical to any species are located immediately downstream of the damsites. While the distribution of mountain whitefish fry (Figure 12) indicates that some fish may spawn immediately downstream of Damsite 7, these represent only a small proportion of the total population.

2) Increased sedimentation will be only a temporary phenomenon and at most would only affect one or two year classes. Accumulated sediments would be scoured from the bottom during freshets and conditions in the stream should return to normal within a short period.

Water Pollution

There are potential sources of water pollution in the vicinity of any large construction project. These include fuels, lubricants and other chemicals, sewage, etc. All of these can have detrimental effects on aquatic life. These materials can affect fish directly as toxicants or indirectly through decreases in oxygen levels as they are aerobically

degraded. Every effort should be made to ensure that such materials do not enter natural waters.

Barriers to Migration

During the construction of either of the proposed dams there will almost certainly be a constriction of flow at the ends of coffer dams, in diversion tunnels, etc. Such constriction will result in increased current speeds which can act as a velocity barrier to upstream migration if it exceeds the swimming performance capability of fish.

Brett (1964 and 1967) has defined three levels of swimming performance: burst, prolonged and sustained.

Burst speed is the maximum swimming speed that a fish can attain. This level of performance can only be maintained for periods of from 20 to 30 seconds. Even within this short period performance is continuously declining. Bainbridge (1961) found that during bursts, "... the maintained speed falls from about 10L/sec, maintainable for only one second of swimming, down to 5L/sec for 10 seconds and further to a cruising speed of about 4L/sec by 20 seconds." (L/sec is the velocity in terms of fish lengths). Fish forced to swim at burst speeds for more than a few seconds become fatigued and are swept downstream.

Prolonged speed is an intermediate level of performance which the fish can maintain for periods of 2 to 200 minutes.

Performance at prolonged speed is characterized by steady performance with periodic vigorous efforts. Continuous swimming at the prolonged level of performance also terminates in fatigue and the fish is carried downstream.

Sustained speeds are those which the fish can maintain indefinitely.

A number of factors including fish size, state of maturity, sex and water temperature can affect swimming performance. Of these the most important is fish size. In absolute terms, the swimming performance of larger fish exceeds that of smaller ones. Thus, larger fish can traverse greater distances at higher velocities than smaller ones. However, "for their total length L , small fish can maintain higher sustained speeds than can larger fish. In the case of sockeye salmon, speed is proportional to $L^{0.5}$ at 15°C . Thus if the size is doubled, the maximum sustained speed increases only by approximately one-half" (Brett, 1967). Fry (1970) has concluded that this relationship ($L^{0.5}$) is true for salmon and trout in general and suggests that many other fish behave similarly.

In passing upstream in fast water, fish, particularly small ones, typically move at burst speed, from one area of low velocity to another. To accomplish this, they are dependent on the eddies which form behind objects (stones, logs, etc.) on the stream bottom or along its banks. A

velocity barrier to migration can occur:

1) Where the bottom is relatively smooth and where there are few areas of calm water. Such conditions commonly occur in culverts, tunnels, etc.

2) In situations where the velocities between resting sites exceed the burst speed of fish.

Because swimming performance is related to length, it often happens that small fish are prevented from moving upstream even though larger fish can easily do so.

Explosives

Many species of fish, particularly those with air bladders, are very sensitive to underwater explosions (Coken and Hollis, 1950; Rulifson and Schoning, 1963; Rasmussen, 1967; McDonald, 1973). This group includes most of the species taken within the study area and all of the sports fish species. Mortalities could be especially severe if major detonations occurred at a time when large numbers of fish were concentrated in the vicinity, possibly due to a velocity barrier such as that described above. This is most likely to occur during the course of major migrations in the spring and fall and less likely at mid-summer or during the winter.

POTENTIAL EFFECTS OF IMPOUNDMENT ON FISH POPULATIONS IN
THE RED DEER RIVER - OPERATIONAL PHASE

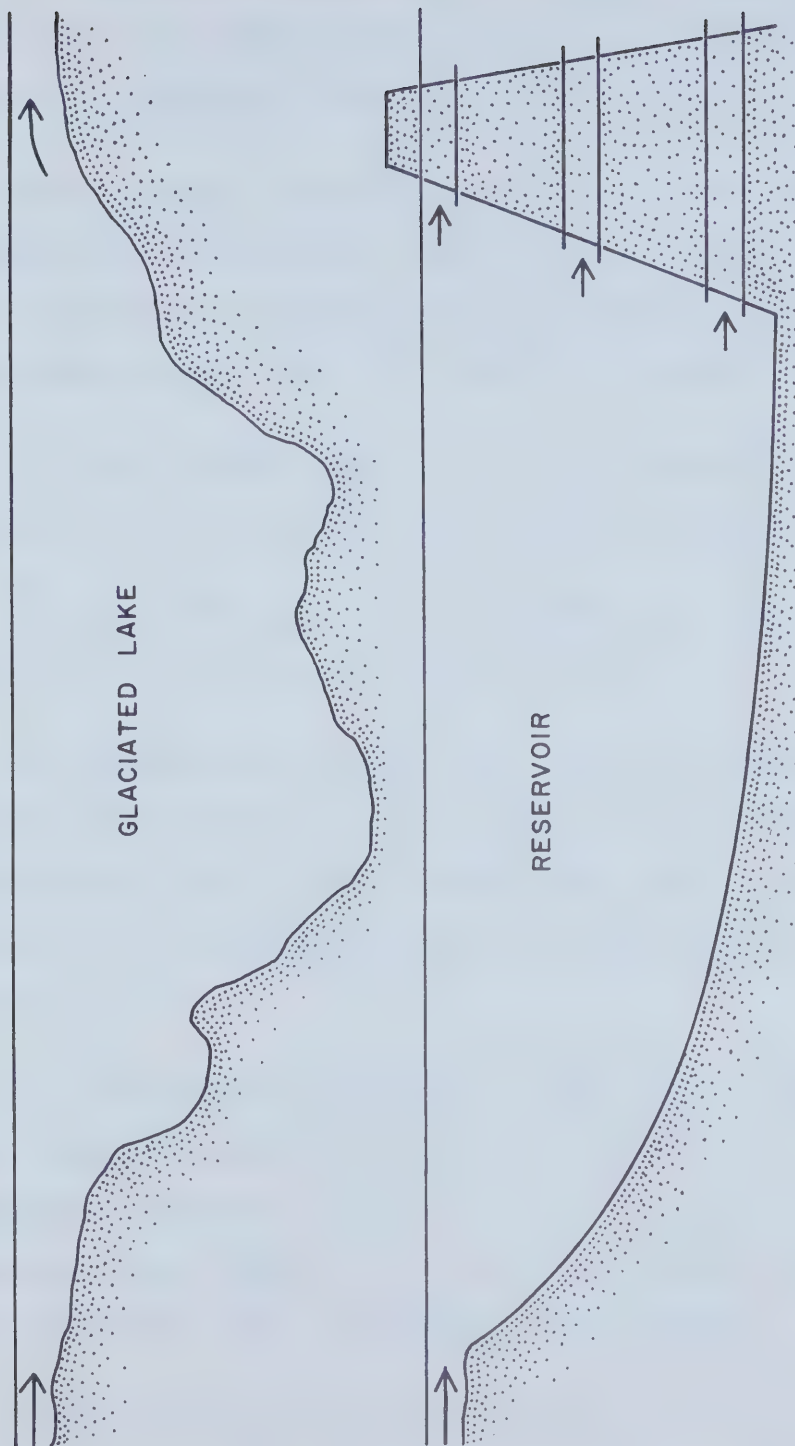
Morphometric Comparison of the Two Reservoirs

The most obvious environmental change that will occur as a result of the construction of a dam at either of the two sites (6 and 7) under consideration will be the formation of a large area of impounded water. While the impoundments will appear superficially similar to natural lakes in the vicinity, they will differ in a number of ways from the glaciated lakes which are the most common type in Alberta (Figure 38). The following summary of the morphometric differences between glaciated lakes and typical reservoirs is based on Nell (1963).

1) Inlets and outlets of glaciated lakes are near the surface but water may leave a reservoir at one of several depths or at two or three levels simultaneously.

2) The lowest depression in a natural lake may occur anywhere in its basin but maximum depth of a reservoir is always near the dam (unless a natural lake is included in the reservoir).

Figure 38. Schematic longitudinal sections of a glaciated lake and a reservoir showing possible paths of flow.



SCHEMATIC LONGITUDINAL SECTIONS OF
A GLACIATED LAKE AND RESERVOIR
(—→ POSSIBLE PATHS OF FLOW)

3) Reservoir bottoms have a regular slope from head to tail that was established by the river before damming. In contrast, glaciated lakes have a non-uniform slope.

The foregoing are general characteristics which the impoundments behind dams 6 and 7 have in common. There are more significant morphological differences however, which are summarized in Table 12. The data indicate the following:

1) The storage capacity at Site 7 would be only 82% of that at Site 6 but the area inundated would be 53% greater.

2) The mean depth of the reservoir at Site 7 would be only half that of the reservoir at Site 6.

3) Because of the low mean depth, the extensive shoreline development and the rarity of steep banks, the reservoir at Site 7 would include much more extensive areas of shallow, nearshore habitat than would the reservoir at Site 6.

4) Because of the extensive shallows, drawdowns at Site 7 would expose a much greater area of bottom than comparable drawdowns at Site 6. This is true in both absolute terms (number of acres) and in terms of the percentage of the total impoundment area exposed.

These differences in the morphometry of the two reservoirs are likely to result in major differences in their ecology.

TABLE 12. Comparison of morphological characteristics of reservoirs at Damsite 6 and Damsite 7 (Raven River site). Based on preliminary data supplied by Department of Environment, Alberta.

DAMSITE 6

	Full Supply Level	Average Winter Drawdown (March)	Maximum Winter Drawdown
Elevation (ft)	3110	3083	3040
Area (acres)	4380	2520	790
Volume (acre ft)	168000	82000	12,600
Mean Depth (ft)	38.1	32.5	15.1
Perimeter (mi)	25	21	9.4
% Perimeter with steep banks	10	-	-
Exposed area (acres)	0	1860	3590
% Total area exposed	0	42.5	82

DAMSITE 7

Elevation (ft)	3180	3161	3140
Area (acres)	6700	2900	1000
Volume (acre ft)	138000	50000	10000
Mean Depth (ft)	20.6	17.2	10.0
Perimeter (mi)	54	30	20
% Perimeter with steep banks	25	-	-
Exposed area	0	3800	5700
% Total area exposed	0	56.7	85.1

Comparison of Potential Environmental Changes

In what follows, comparisons are made of the changes in the environment which could result after the dams have become operational. Wherever possible, the effects of the two dams are compared.

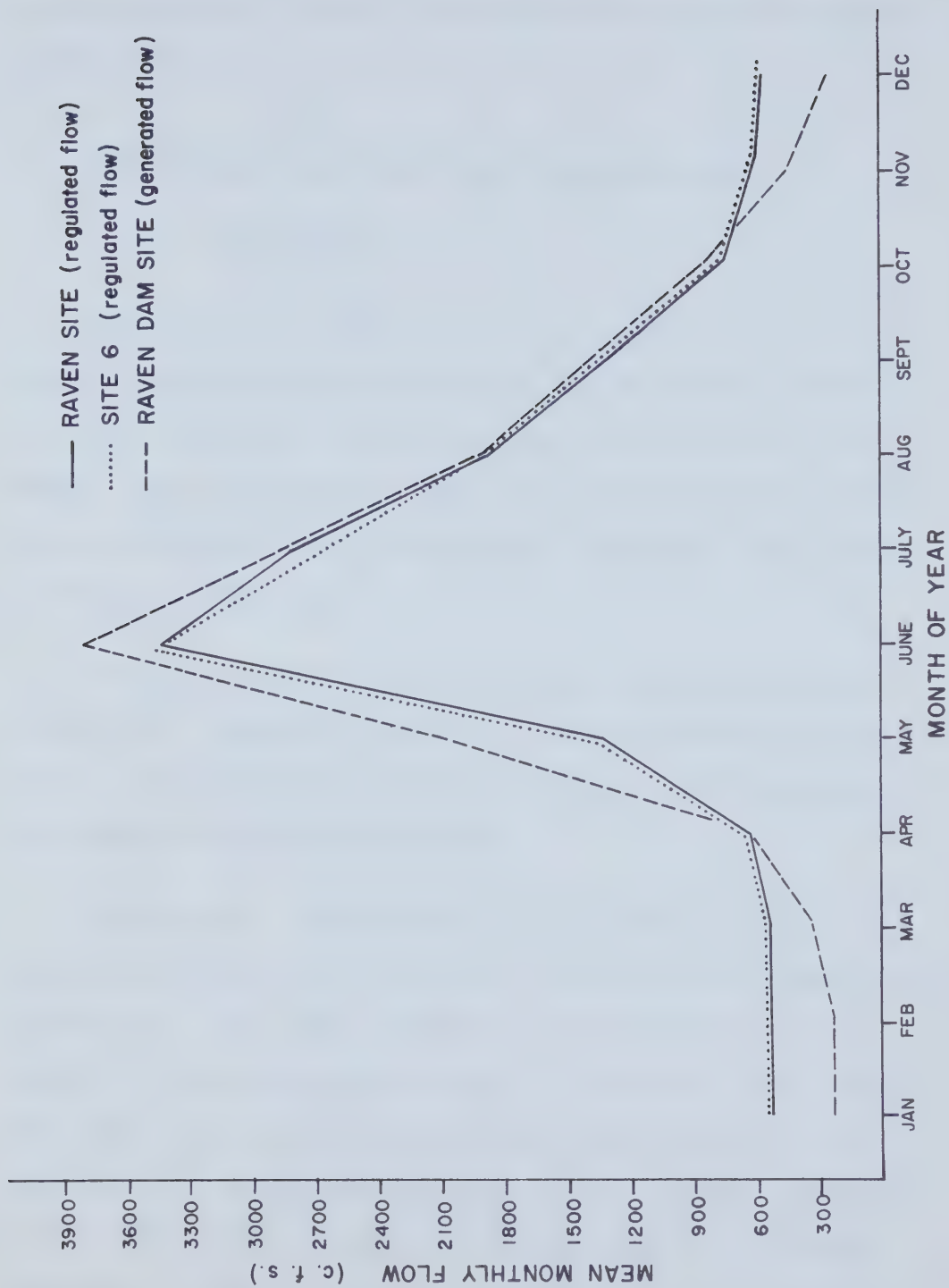
Hydrograph

The operation of either damsite will affect the hydrograph of the Red Deer River downstream (Figure 39). Because the storage capacity of the reservoir is small in comparison with the total discharge of the Red Deer River, the effect of impoundment on flood levels will be limited. The major biologically significant change in the downstream hydrograph will be a pattern of release which will nearly double and stabilize average natural discharge during the winter period. The projected pattern of discharge is very similar for the two reservoirs.

Water Quality

It is likely that the closure of the dams will have significant effects on the physical and chemical characteristics of water both within the reservoir and in the river downstream. The major parameters describing water quality likely to be affected by impoundment are temperature

Figure 39. Hydrograph of the Red Deer River showing changes in mean monthly flow that can be expected as a result of construction of a dam at Site 6 or at the Raven River Site.



and oxygen conditions, suspended sediment loads and turbidity, concentrations of organic nutrients and levels of primary productivity.

Water Temperature and Oxygen Concentrations

1) Impoundment

Because of the large volumes of water which must be heated and cooled, reservoirs tend to be cooler than their tributary waters in the early summer but warmer in late summer, fall and winter. This has important effects which will be discussed in the following section on temperature conditions downstream.

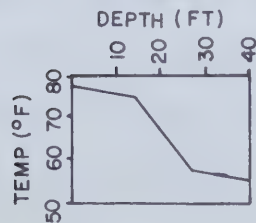
During the summer, many reservoirs become thermally stratified. Typically there is a three-layered structure (Figure 40) with each of the three layers distinguished by its temperature characteristics:

Epilimnion. The uppermost of the three layers, characterized by relatively high temperature and high oxygen saturation. This layer circulates continuously as the result of wind-generated currents so that all parts of the water mass come in frequent contact with the air. Thus, they are well oxygenated and, during the summer, are warm. Most of the primary productivity (production of organic compounds by green plants) takes place in the epilimnion.

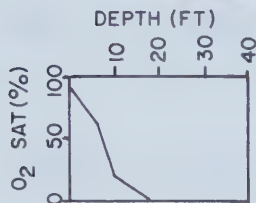
Figure 40. Temperature and oxygen stratification in a reservoir situation and how it can be affected by hypolimnial drawdown. The example is a highly eutrophic reservoir in Ontario (Johnson and Berst, 1965). Oxygen deficits of this magnitude are unlikely to develop in either of the proposed Red Deer River reservoirs.

TEMPERATURE

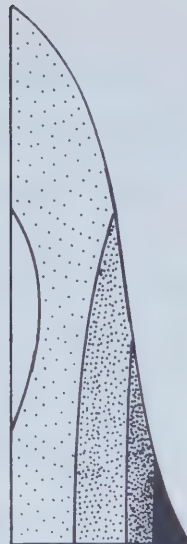
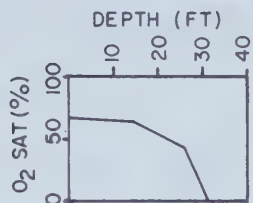
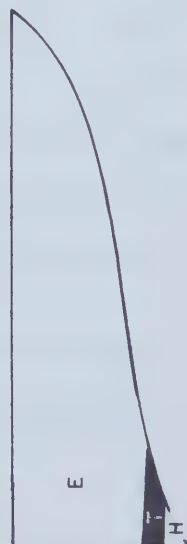
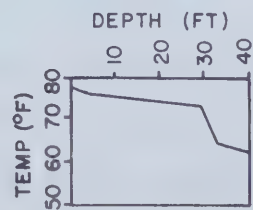
AUGUST 3, 1961



OXYGEN CONCENTRATION



AUGUST 7, 1963



Thermocline. The middle layer, characterized by a rapid decline in temperature with depth. If the lake is oxygen deficient, there may also be a decline in oxygen levels.

Hypolimnion. The lowermost layer, characterized by uniform low temperatures. In productive lakes, where large amounts of organic materials produced in the epilimnion drift down into the hypolimnion where they are degraded aerobically (consuming oxygen), the hypolimnion may become oxygen deficient. In some cases, oxygen may be undetectable (Figure 40).

Stratification of the kind described is most likely to develop in reservoirs which are:

a) *Deep.* In shallow reservoirs (20 feet or less), wind-generated currents bring about a mixing of the entire water column. In shallow lakes, what stratification does occur is usually the result of unusual circumstances (*e.g.* a period of very hot, wind-free days) and is temporary.

b) *Protected.* Wind is the primary force bringing about mixing of the water column and in open, windswept areas, stratification can be inhibited.

c) *Drained from the surface.* Natural lakes and reservoirs flowing over spillways drain only from the surface and the outflow consists almost entirely of epilimnial water. Under these circumstances stratification is maintained as

long as air temperatures remain high, warming the inflowing water. However, in many reservoirs, hypolimnial water is released by low-level discharge through the dam. These cooler, deeper waters are not replaced as long as air temperatures remain high. As a result, the hypolimnion is considerably reduced in volume (Figure 40) or entirely eliminated.

d) *Large in relation to stream discharge.* Reservoirs with high flushing rates are less likely to develop a stable pattern of thermal stratification than are reservoirs with high volume/discharge ratios.

In assessing the two reservoirs which would be formed behind the proposed dams at Sites 6 and 7, it is apparent that if surface spillage is practiced, persistent thermal stratification could develop in either one. At the full supply level which will prevail throughout the summer, maximum depths will exceed 80 feet in both reservoirs. However, because of its greater mean depth, the volume of hypolimnion is likely to be greater in Site 6 than in 7. A relatively large area of shallow water in the reservoir behind Site 7 will be covered with warm epilimnial water throughout the summer. It should be emphasized that neither reservoir is very large in relation to discharge. At full supply levels, flushing rates will be in the order of 31 days for Reservoir 6 and 25 days for Reservoir 7. If low-level hypolimnial discharge is practiced during the summer

period, it is likely that the hypolimnion will be drastically reduced or eliminated in both reservoirs.

2) Downstream

In general, in comparison with natural temperature regimes, impoundment delays downstream river temperature increases in the spring and declines in the autumn because the relatively large volumes of water take more time to reach air temperature (Neel, 1963). Where hypolimnial release is practiced, normal temperature regimes may be further modified. Spence and Hynes (1971) studied the downstream temperature effects of the Shand Dam on the Grand River, Ontario, and found that, "with the release downstream of cold hypolimnial waters from the dam there was a lag of about four weeks in the spring rise of water temperatures and a maximum summer temperature 7°C lower than upstream."

It is unlikely that oxygen levels downstream of the dam will be significantly reduced. Even if hypolimnial release of low oxygen water is carried out, reoxygenation should be very rapid in the release valves and in the turbulent, high velocity area just downstream of the dam.

Supersaturation of both oxygen and nitrogen can occur downstream of dams and cause mortality to fish. However, discussions with engineering consultants involved in the design of proposed dams on the Red Deer River indicate that

with the type of release valve contemplated, supersaturation is not likely to be a problem.

Suspended Sediment Loads and Turbidity

1) Impoundment

In large reservoirs there is complete or near-complete removal of carried-in silt and other suspended materials (Neel, 1963). Much of this material is incorporated in deltas near the mouths of tributary streams. Blench and Associates Ltd. estimate that approximately 90% of all sediments and 100% of the bed load entering the proposed reservoirs in the Red Deer River will settle out without passing downstream.

2) Downstream

Typically, below dams there is scouring and consequent reduction in the sediments incorporated in the stream bottom. This results because:

a) velocities are usually higher than those prior to dam construction,

b) the bed load has been reduced within the impoundment but the potential for normal regime bed load still exists. The usual effect is that small gravel and fines are moved some distance downstream leaving the area immediately below

the dam paved with larger cobbles and boulders.

The indications are that there will be a net improvement in the water quality downstream of the dam because of reduced suspended sediments and turbidity. It is also likely that there will be some improvement in the gravel substrate due to scouring of the heavily sited gravel. It is likely that this effect will be limited to the length of stream between the dam and its major downstream tributaries (*e.g.* the Little Red Deer, Medicine and Blindman Rivers) all of which carry significant silt loads.

Nutrients and Primary Productivity

1) Impoundment

Neel (1963) points out that glaciated lakes begin as bodies of water with low productivity (oligotrophic) and tend to become more productive (eutrophic) as time passes. Reservoirs, in contrast, inundate rich bottom lands from which mineral nutrients and organic materials are leached immediately after closure (Sylvester and Seabloom, 1966). The relatively high initial levels of plant nutrients encourage the development of dense algal populations with a high primary productivity. Algal populations and primary productivity fall as the rate of leaching declines. Thus reservoirs tend to be most productive (eutrophic) early, and productivity tends to decline (to oligotrophy) with age. Chamberlain (1972) found high initial values for primary

productivity (C^{14} method) in a new reservoir attributable to flooding of organic material. The high values were transitory and subsequent patterns of primary productivity were similar for the new reservoir and an older reservoir utilized as a control.

The increase in primary productivity will most likely be greater in the Raven River (Site 7) reservoir than in the reservoir in Site 6, due to the much larger floodplain at Site 7.

2) Downstream

There appears to have been very little study of the downstream effects of increasing nutrient loads and primary productivity. However, the increased nutrient loads and higher productivity which result from the leaching of soils and organic materials during the initial flooding of the reservoir should result in a corresponding increase in productivity downstream. This effect should be temporary, as it is in the reservoir. The subsequent reduction in productivity will be greatest if, during the summer, only epilimnial waters are discharged over a spillway. If nutrient-rich hypolimnial water is released, primary productivity downstream might be maintained at a higher level. This effect could be at least partially offset by the lower temperature of the hypolimnial water. On the other hand, reductions in turbidity by increasing light penetration, can increase primary productivity.

One of the common downstream effects of impoundment is the development of luxurious growths of attached, filamentous algae. Neel (1963) states that, "clarification, discharge of nutrients from deeper strata, stabilization of discharge, and decreased bank and bed erosion collectively or individually promote greater growths of algae than most streams develop before damming." These growths provide excellent habitat for many species of benthic invertebrates. The latter are very important fish foods.

Invertebrate Populations

Invertebrates are the small animals including insects, crustaceans, worms, etc. which inhabit lakes, reservoirs and streams and which constitute a large proportion of the food of fishes. Invertebrates of importance to fish may be classified as follows:

a) *Terrestrial invertebrates* are animals (predominantly insects) with land-based life histories which inadvertently enter water. Examples would be grasshoppers, bees, caterpillars, earthworms, etc.

b) *Benthic invertebrates* are the animals which inhabit the bottoms of bodies of water. They include a variety of insects (mayflies, stoneflies, midges, etc.) with aquatic larval forms and winged adults; molluscs (clams and snails), crustaceans (amphipods or scuds), oligochaetes (segmented

worms) and others.

c) *Zooplankters* are the invertebrates which inhabit the open waters of lakes, reservoirs and, to a lesser extent, large streams. The majority are microscopic crustaceans, most commonly cladocerans and copepods

1) Impoundment

Nilsson (1961 and 1964), Runnström (1955), Kimsey (1957), and Paterson and Fernando (1970) have commented on the colonization of new reservoirs by the invertebrate fauna. The following appears to be a typical pattern:

a) During the very early stages of initial flooding, terrestrial insects and earthworms constitute a large proportion of the total invertebrate biomass (by weight).

b) Zooplankton populations, particularly Cladocera, increase rapidly then decline to lower but still substantial levels.

c) Benthic invertebrate populations increase substantially during the initial flooding as many groups of stream-dwelling invertebrates (oligochaetes, nematodes, oribatoid mites and chironomids) invade the new habitat.

d) The terrestrial- and stream-derived invertebrate fauna is largely replaced within a few months by truly a limnophilic (lake-dwelling) fauna which invades the reservoir

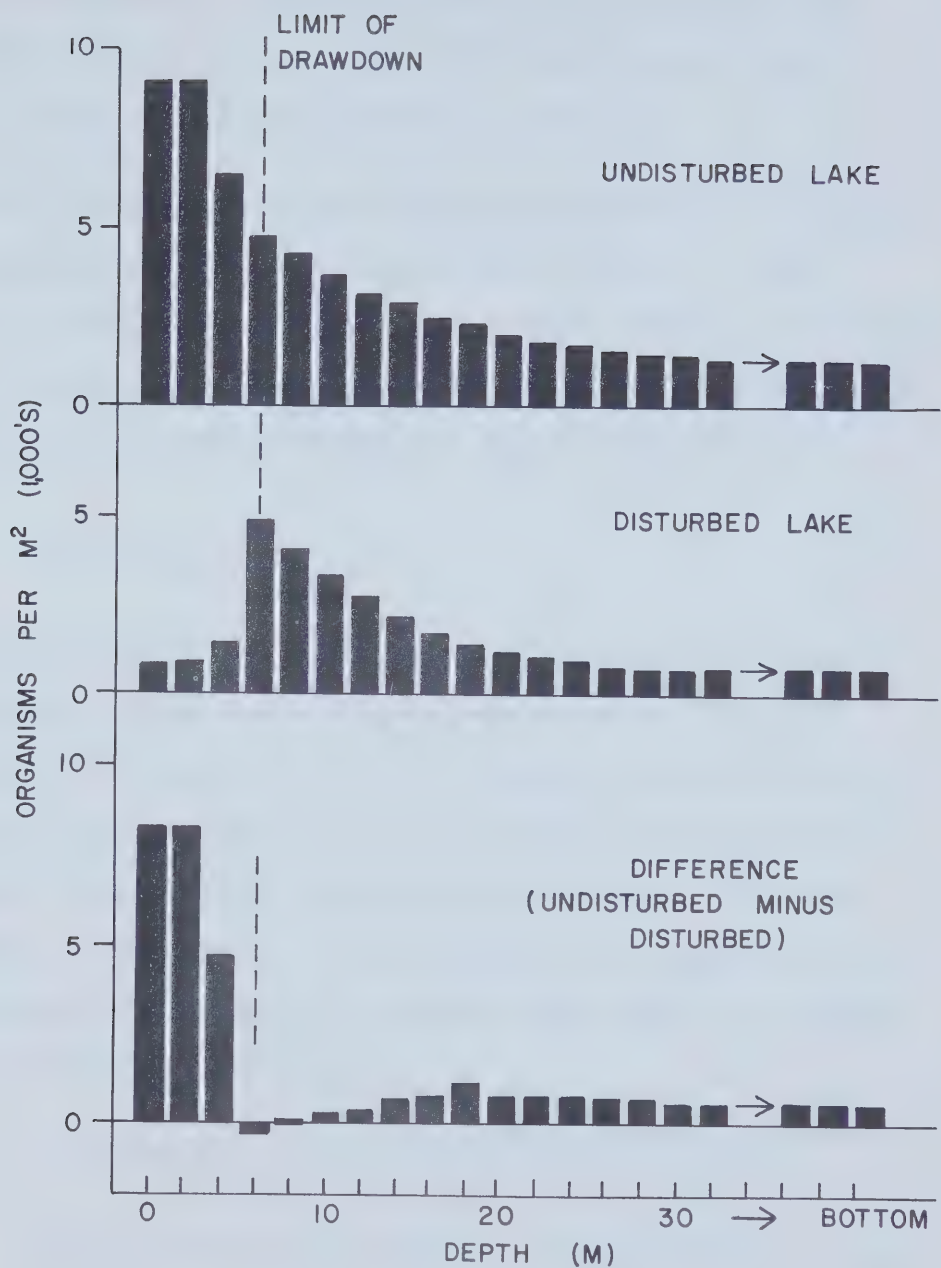
during the summer temperature rise.

e) During the winter, many species are eliminated by freezing and ice scour as lake levels decline. The groups that suffer most are the larger crustaceans (the amphipods such as *Gammarus*, an important fish food), the larvae and nymphs of large insects and the molluscs. Among the Chironomidae, the tribe Chironomini disappear in favour of the Tanytarsini.

f) With respect to species composition, it is likely that the invertebrate fauna is essentially complete by the end of the first summer of the reservoir's existence, though it may be several years before the fauna is stabilized in terms of relative abundance.

The overall pattern is one of high invertebrate densities early in the life of the reservoir and lower, more stable levels as the reservoir ages. The most striking difference between reservoirs and natural lakes is in the depth distribution and overall densities of their benthic invertebrate populations (Figure 41). Natural lakes have their maximum densities in shallow water whereas in regulated lakes and reservoirs the greatest densities occur at depths below the limit of maximum drawdown. The example given is from Sweden but a similar pattern has been observed in the Kananaskis Reservoirs (Fillion, 1964). As a result of the reduction in the benthic fauna which occurs because of the

Figure 41. Comparison of numbers of benthic invertebrates in an undisturbed lake environment versus those in a disturbed lake environment.



unstable environment between the full supply level and the limit of drawdown, regulated lakes and reservoirs are generally less productive of fish food organisms than natural lakes which are otherwise comparable.

It is likely that the effects of drawdown on benthic invertebrate populations will be much greater in the reservoir above Damsite 7 than that above Damsite 6 because of the greater area, proportionately and in absolute terms, which will be exposed during the winter (Table 12).

2) Downstream

Spence and Hynes (1971) compared the benthic fauna upstream and downstream of a dam on an Ontario stream. They found the overall density of benthic invertebrates had increased downstream of the dam but that the community structure had undergone considerable change. This was reflected particularly in the Ephemeroptera (mayflies) and Trichoptera (caddisflies) in which three types of changes were discernible downstream:

- a) a reduction in the total number of species
- b) an increase in the numbers of individuals of some species
- c) the replacement of some species by closely related ones.

The authors ascribed these changes to three primary factors which affected benthic invertebrate populations in the same general way as mild organic pollution.

a) alteration in the temperature regime as a result of low level drawdown so that water temperatures were considerably lower in summer,

b) abundant development of attached filamentous algae (*Aufwuchs*) below the dam which provided attachment and a large number of microhabitats for benthic invertebrates,

c) outflow of organic material, particularly phytoplankton and zooplankton, from the impoundment. The zooplankton are heavily utilized by filter-feeding benthic invertebrates, such as web-spinning caddisflies, and their numbers are rapidly reduced downstream of lake outlets and dams (Hynes, 1970).

Briggs (1947) also observed increased benthic invertebrate populations downstream of an impoundment in California. However, Lehmkuhl (1972) demonstrated a marked reduction in both density and number of species downstream of a very large reservoir, Diefenbaker Lake, Saskatchewan. This reduction was detectable for 70 miles downstream.

It is likely that there will be an increase in benthic invertebrate populations downstream of the proposed dams on the Red Deer River due to increased productivity of suitable

substrates (rocks and cobbles and filamentous algae). There will likely be a change in the species composition with an increase in the abundance of filter-feeding caddisflies, blackflies, etc. This effect will probably be greater downstream of Site 7 than Site 6 if, as seems likely, the former is the more productive impoundment.

Changes in the benthic invertebrate fauna will be most noticeable immediately downstream of the dam and, within a few miles, it is likely that more typical stream-dwelling forms will replace the filter-feeding types. However, persistent increases in densities may occur much further downstream as a result of reduced sediment loads and improved overwintering conditions resulting from greater, better oxygenated, winter flows. Neel (1963) notes that benthos development is benefitted by reductions in silt loads and regulation which promotes uniformity of discharge.

Fish

1) Upstream Effects

Upstream effects are those which would affect fish populations upstream of the reservoir, both in the mainstem of the Red Deer River and in its tributaries. These have mainly to do with changes in the distribution and relative abundance of fish species. These come about because of the presence downstream of the impoundment and dam and not

because of any physical change in the upstream portion of the drainage.

Hynes (1970) discusses the problem of upstream effects and states that the biological effects of impoundment may be found far upstream. *The major effects result from the blockage of upstream migration and the elimination of, or reductions in, migratory fish populations.* Neel (1963) notes that, "dams or high velocities of reservoir discharges often form effective barriers against the migration of fishes, and regions just below stilling basins are often crowded with frustrated piscine migrants, monotonously working their way, time after time, towards the overpowering jets of flood-control releases or jam-packed into quiet pools or swimming endlessly in the boils below power plants."

Disruption of migration patterns may sometimes be beneficial (e.g. the elimination of predatory eels from the upstream reaches of New Zealand streams which resulted in increased populations of trout; Hobbs, 1948). More often, the effects are disadvantageous (*e.g. the numerous examples of anadromous salmon populations eliminated when their spawning grounds were cut off to access from the sea*).

A further upstream effect can result when large populations of certain species develop in impoundments then migrate upstream into streams where they were previously absent or rare (Ruhr, 1957). This can come about because:

a) the species has become extremely abundant in the reservoir and expands into formerly marginal habitats, or b) the reservoir floods falls, rapids, beaver dams, etc., which blocked fish passage prior to impoundment. This may be advantageous if the expanding species are desirable (*e.g.* trout) but disadvantageous if coarse (*e.g.* white and longnose suckers) or less valuable sports species (*e.g.* pike) become abundant in areas now habitat for trout and whitefish.

Erman (1973) describes upstream changes in fish populations following the impoundment of Sagehen Creek, California. Prior to impoundment minnows (dace and redbreast shiners) dominated the fish fauna (71% combined), followed by the mountain and Tahoe (*C. tahoensis*), suckers (17.8% combined); rainbow, brown and brook trout (8% combined) and the mountain whitefish (3.2%). *After impoundment, suckers become dominant (79.2% overall) and all other groups declined--dace and shiners to 14.4%, trout to 5.1% (rainbow trout increased but brook trout disappeared entirely) and whitefish to 1.5%.* Erman was unable to correlate these changes in fish fauna with any physical changes in the upstream segments of Sagehen Creek. It appeared to be entirely the result of the presence of the reservoir.

No precise prediction of the upstream effects of the proposed dams on the Red Deer River is possible because the interrelationships of the various fish species are far too complex. However, with respect to sports species, some

general effects are predictable.

a) *Unless effective fish passage facilities are provided, either dam will block the upstream migration of large numbers of mountain whitefish, the most abundant sports fish in the Study Area.* A large segment of the population of this species migrates from feeding and overwintering downstream of the damsites to the major spawning areas upstream. There will probably be an overall reduction in the populations of this species because, unless effective fish passage facilities or alternative spawning areas are provided, fish moving downstream past the dam will be unable to return upstream to their traditional spawning areas. Reproduction would then be dependent on the segment of the population which does not migrate far enough downstream to pass the dam.

b) *The upstream migrations of goldeye and mooneye would be blocked.* It appears that these species only enter the area immediately upstream of the dams on short, summer feeding excursions. This area is on the periphery of each species' range and does not appear to be in any way critical to their survival. It is unlikely that blockage of this movement will have any detectable effect on overall population size.

c) Two warm water species, the northern pike and walleye, occur in limited areas upstream of the proposed impoundments but are not known to spawn there. Both

species would presumably be cut off from spawning areas downstream and might decline in numbers upstream of the impoundments.

d) *If the dam is built at site 7, it will effectively flood all warm water habitat above the dam.* The northern pike and walleye will become rare or be eliminated above the dam if they are unable to successfully reproduce in the reservoir.

2) Impoundment

Impoundment results in profound changes in the environment within the flooded area with correspondingly major effects on fish populations. Kimsey (1957) describes a situation in impounded waters in California and the lower Colorado River which appears to be typical of fish populations in reservoirs.

"Over a period of years, following construction, the reservoirs experience a typical pattern of high initial fishing success, a sharp decrease, and then a gradual rise to a fishery somewhere near half the magnitude of the initial phase. The decrease is believed to be the result of the high initial fertility, characteristic of newly farmed lands, being leached out by repeated fluctuation. The readjustment of the fishery to a lower level is the

result of its adjustment to the basic fertility of the basin."

Changes can occur not only in population size but in the growth of individuals within populations. Runnström (1955) studied the effects of regulation of lakes in Sweden. He described a great increase in the population size and growth rates of Arctic char immediately after regulation followed by a marked decrease in both numbers and growth. He noted that a similar pattern has been observed among Swedish whitefish populations in regulated lakes. He ascribed this phenomenon to changes in the production of fish food.

There may also be changes in the relative abundance of various species, as species well adapted to the effects of impoundment and regulation increase in abundance while ill-adapted species decline. Nelson (1965) has provided a detailed description of changes in fish populations in the Kanananskis River Reservoirs in Alberta. His major findings concerning the effects of impoundment on fish populations were that:

- a) mountain whitefish show no signs of having been unfavourably affected,
- b) brown trout have increased in numbers and caused a marked decline in populations of rainbow trout, brook

trout, cutthroat trout and Dolly Varden where their ranges overlap. The two latter species, both native to the drainage, are now rare,

c) longnose sucker populations have declined in some impoundments but populations of the introduced white sucker have greatly increased,

d) lake chub, another species introduced into the Kananaskis System, have also increased greatly in some reservoirs.

All of these species occur in the vicinity of the proposed dams on the Red Deer River.

Posewitz (1962) described the fish populations of a small coldwater impoundment on a tributary of the Missouri River System in Montana. White and longnose suckers together constituted 84% of all fish taken by gillnet (N=5,456). Of the remainder (N=882), rainbow trout were most abundant (69%), followed by brown trout (30%), brook trout (0.7%) and mountain whitefish (0.2%). Approximately 80% of the captured rainbow trout were marked hatchery releases and it would appear that without this assistance the naturally reproducing brown trout population would exceed that of rainbow.

Fillion (1964) discussed the success of suckers, particularly the white sucker, in the Kananaskis Reservoirs

and suggested that this success was in part, the result of their ability to utilize chironomid larvae, the dominant group of benthic invertebrate in these reservoirs, while they are still associated with the bottom substrates. In contrast, chironomid larvae are largely unavailable to whitefish and trout which have a very different feeding behaviour and can best utilize chironomid pupae and imagoes (winged adults) when these are present underwater or at the water surface. The hatching season for chironomids is short and intense and for this reason the period during which these life history stages are available to fish is limited in comparison with larvae which are present throughout the year.

With respect to the two reservoir sites under consideration on the Red Deer River, it is not possible to make precise predictions concerning the future of fish populations in the impoundments. However, the following sequence is suggested.

a) *It is likely that both reservoirs will follow the typical pattern with an overall increase in fish production immediately after impoundment followed by a decline. The increase in productivity would probably be greatest in impoundment #7 because of its greater potential primary productivity.*

b) *Coarse fish are likely to dominate populations in both reservoirs. Of these, the white sucker will probably*

constitute the largest proportion of the total biomass by weight. It appears to be better adapted to the fluctuating movements of shallow reservoirs than is the longnose sucker (Nelson, 1962). The mountain sucker, though presently numerous in the area, is primarily an inhabitant of swift running water and is unlikely to do well in impoundments. Some species of small forage fish already numerous in the vicinity of the proposed reservoirs, are likely to do well in the impounded waters. These include the troutperch, longnose dace and, particularly, the lake chub.

c) *The mountain whitefish will probably continue to be the most numerous sports species.* Nelson (1965) found it to be the most abundant sports species in the Kananaskis River and in Kananaskis and Barrier Reservoirs. It is possible that many of the fish which now overwinter in the deeper, slower moving portions of the Red Deer River below the damsites, will remain in the impoundments throughout the winter and will not be lost from the reproductive segment of the population.

d) *Of the trout and char species, the brown trout is the one most likely to do well in impoundments.* It is already the commonest salmonid in the slower, warmer portions of Stauffer Creek (Shirvell, 1972) and the Raven River, and could soon invade Reservoir #7 where, particularly in the first years after flooding, the brown trout would be expected to do extremely well. Reservoir 6, further removed

from the major spawning and rearing areas of brown trout on the upper Raven River and Stauffer Creek, would be invaded more slowly but here too it is likely that brown trout will come to dominate trout and char populations. It is possible however, that the exploitation of the impoundments by brown trout will be less than maximal due to the flooding of a portion of the presently utilized spawning habitat by Reservoir 7 and/or by the continuing deterioration of spawning grounds described by Shirvell, 1972. In other words, the population may be limited by the availability of spawning habitat and not by the potential for exploitation in the newly created impoundment.

e) Of the other trout and char, experience in the Kananaskis System (Nelson, 1962) and in a small cold water reservoir in Montana (Posewitz, 1962) suggests that *the rainbow trout is likely to do better than the brook trout, Dolly Varden or cutthroat trout.*

f) *Of the warm water game species, the pike is the only one which appears likely to persist in either of the reservoirs.* The other species, goldeye, mooneye and walleye) appear to be transients which will be blocked by the construction of the dams. Conditions for this species would appear to be most suitable in the extensive shallow areas which will develop in Reservoir 7. The populations may be limited by the availability of spawning areas. No young-of-the-year have been taken and no spawning areas are known

upstream of Damsite 6. The nearshore vegetation on which pike spawn is characteristically absent from fluctuating reservoirs. It seems unlikely that pike will become very numerous in either reservoir.

3) Downstream

One of the major consequences of the construction of a dam on the Red Deer River will be a stabilization in winter flows downstream of the dam. There will also be some reduction in flood peaks but the major effect will be an increase in winter discharges which will nearly double natural levels. It is likely that these changes will be beneficial to fish populations both indirectly, by increasing primary productivity and populations of benthic invertebrates and directly by improvement in winter conditions, particularly oxygen levels. However, though *it is likely that stabilization of streamflow downstream of the dam will benefit fish populations as a whole*, there will be changes in the relative abundance and population structure of individual species. Unfortunately, this is one of the least studied aspects of impoundment and it is difficult to predict what these changes might be. One possibility is that the *reduced sediment loads in the stretch of stream below the dam might favour mooneye over goldeye*. The latter appears to be adapted to existence in turbid waters while the former occupies cleaner streams (Scott and Crossman, 1973). Dr. M. Paetz

(personal communication) reports that at Bassano Dam, Alberta, there was a decline in goldeye populations which coincided with a marked reduction in turbidity.

One of the few studies of the downstream effects of mainstem impoundments on fish populations was carried out by Spence and Hynes (1971) on the Grand River, Ontario. They found that four species of cyprinid fishes (minnows) found upstream of an impoundment were absent downstream. They attributed this to the effect of the lowered water temperatures resulting from hypolimnial release which remained below the levels necessary for successful spawning in these species. Little is known of the behaviour and physiology of most of the fish spawning in the Red Deer River and it is impossible to predict whether a similar situation might occur there, particularly in the absence of any detailed information concerning the temperature characteristics of release water.

One species of warm water game fish, *the walleye*, may actually benefit from the presence of a dam. In streams, this species typically spawns in white water frequently utilizing rapids below impassable falls and dams (Scott and Crossman, 1973). No spawning areas have been identified anywhere within the study area and, if walleye do utilize the area immediately downstream of the dam, there may be an increase in the population of this extremely valuable sports species.

The population of one other sports species, *the mountain whitefish*, is likely to be adversely affected downstream of the dam. As far as is known, the spawning of this species occurs upstream of both damsites and, with the construction of the dam, the segment of the population which now feeds and overwinters downstream of the dam will be completely separated from their traditional spawning areas. This problem may be partially alleviated if suitable alternative spawning areas result from the scouring and cleansing of the stream bottom which is likely to occur immediately downstream of the dam, if an artificial spawning channel is provided downstream, or if adequate fish passage facilities are constructed.

CONCLUSIONS

These are the general conclusions of the study:

- 1) Stream habitats within the Red Deer River drainage can be divided into two broad categories, warm water and cold water. On the Red Deer River itself, the division between the two types is in the vicinity of the two damsites.

- 2) The cold water fish fauna inhabits the cooler, less productive, faster flowing waters and is dominated by the mountain whitefish and several species of sucker. Aside

from the mountain whitefish, cold water sports species include the brown trout, brook trout and, rarely, the Dolly Varden and rainbow trout.

3) The warm water fish fauna inhabits warmer, more productive, more turbid, slower moving waters. The warm water fauna is dominated by various species of suckers and small forage fishes. The most important sports species are the goldeye, walleye, northern pike and, to a lesser extent, the mooneye and sauger. The distribution of the mountain whitefish overlaps that of the warm water species to a point downstream of the city of Red Deer.

4) The major effect of either dam upon fish distribution is that they would bisect the present range of the mountain whitefish, separating juvenile and overwintering fish from known spawning areas upstream.

5) The net effect of dam construction on fish populations will be beneficial, trading off a segment of the mountain whitefish population in return for improved winter conditions (increased flows and higher oxygen levels) throughout the Red Deer River downstream of the dam.

6) A dam, which provides increased winter flow as well as improved oxygen conditions is preferable to any system (*e.g.* U-tube aerators, etc.) which improves oxygen conditions only.

7) These benefits will be short-lived unless stringent measures are applied to control increases in organic loadings from cities and other sources along the river.

RECOMMENDATIONS

Construction Phase

Sediment Loads

While it is not anticipated that short-term increases in sediment loads resulting from construction will have any serious effects on fish populations in the Red Deer River, *care should be taken to minimize long-term soil erosion and sediment production within the project area.* Measures to reduce this should be part of the construction plan and contract specifications. Examples of appropriate measures are described by Sciandrone (1974). These include seeding of exposed soils, mulching, protective plastic sheeting, and other measures to promote slope stabilization.

Water Pollution

Here again, contract specifications should require *proper storage and disposal of materials (fuels, lubricants, cement, salt, sewage, etc.)* likely to contaminate natural

waters.

Barriers to Migration

If a decision is made to provide permanent fish passage facilities after the closure of the dam, *care should be taken to ensure that passage is provided during the construction phase.* If this is not done, several year classes of mountain whitefish might be severely reduced because the segment of the adult population which overwinters downstream cannot reach their traditional spawning grounds. This is not so critical if total closure is planned because the provision of temporary facilities would only delay the inevitable total obstruction to migration. Even in the latter case it might be useful to provide temporary facilities so that a maximum number of fish could be passed upstream before final closure. Hopefully, these would overwinter in the impoundment after spawning rather than moving over or through the dam, providing a large stock of adult fish to perpetuate whitefish populations above the dam. However, even if this is not done, it is likely that there is a residual population above the dam which would persist even if the bulk of mature fish were trapped downstream.

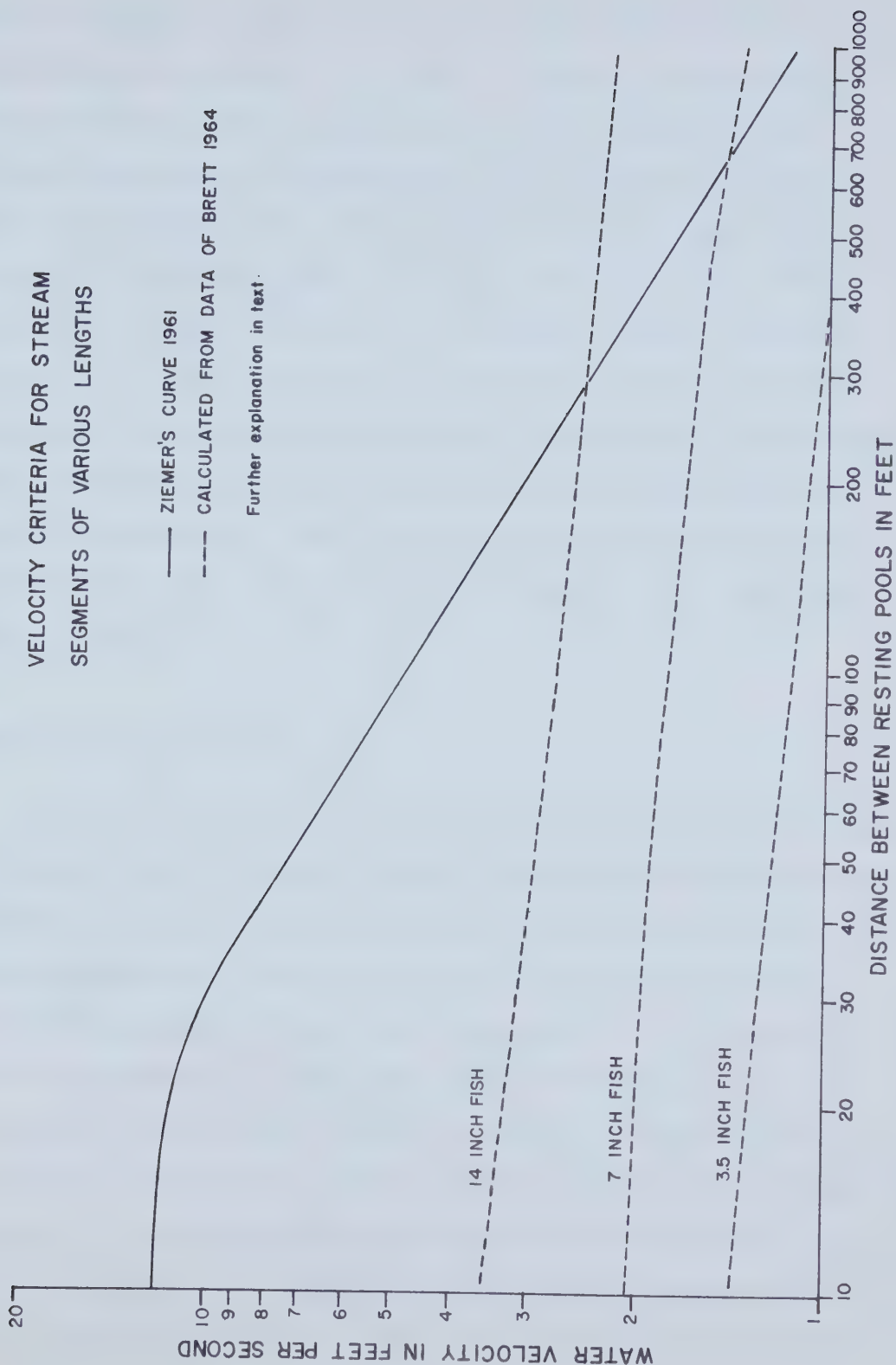
Velocity criteria are difficult to define for the species of fish likely to undertake significant migrations past the damsites in the Red Deer River. None has been the

subject of studies of swimming performance. Studies related to fish passage through culverts indicate that velocity criteria should be related to the distance between resting pools with higher velocities permissible for short distances than for longer ones. For example, the Oregon State Game Commission (Anonymous, 1971) has established maximum permissible water velocities for cylindrical culverts up to 100 ft in length at 8 feet per second for adult salmon and steelhead and 4 fps for adult trout. Maximum water velocities for culverts in excess of 100 feet are 6 fps for salmon and steelhead and 2 fps for adult trout. Of these species, the trout is closest in size and, presumably, swimming performance to the mountain whitefish, the species most likely to be affected by barriers to migration.

Another approach is to graph maximum permissible water velocities over a range of distances. Zeimer's (1961) curve for salmon is illustrated in Figure 42. However, his curve is not directly applicable to the mountain whitefish because it was developed for much larger salmon. These fish average 28 inches in length, nearly twice the size of the largest (14.6 inches or 372 mm) mountain whitefish taken during this study. However, it is possible to calculate curves for smaller fish using data from a fatigue curve for yearling sockeye salmon developed by Brett (1964). Calculated curves for three sizes of fish (14, 7 and 3.5 inches fork length) are included in Figure 42. These curves indicate

Figure 42. Velocity criteria for stream segments of various lengths.

VELOCITY CRITERIA FOR STREAM SEGMENTS OF VARIOUS LENGTHS



that velocities should not exceed 4 fps even for 14 inch fish moving as little as 10 feet. However, recent work with grayling (MacPhee and Watts, 1974) indicates that these values may be conservative and that most 14 inch fish can successfully move upstream 60 feet in the face of a 5 fps current. It would appear that to ensure the successful upstream passage of at least the largest, mature mountain whitefish, *water velocities in diversion works should not exceed 5 fps for distances greater than 60 feet.* Velocities may be somewhat greater if the distances between resting areas are reduced. This can be achieved through the use of baffling or rock groins placed at intervals to create eddies (Clay, 1961).

Timing of Dam Closure

The final closure of the dam should be timed, if possible, to ensure that a maximum number of mature mountain whitefish remain upstream. For this reason, final closure should take place during the period when fish are on their upstream spawning grounds, the period from August 15 to October 1.

If large numbers of fish are trapped downstream after closure, consideration should be given to capturing and trucking fish over the dam to provide a population of spawning adults. It is anticipated that this operation would be of short duration, two seasons at most, as it is expected that mature fish would overwinter in the reservoir and be

unobstructed during subsequent spawning migrations.

Explosives

Care should be taken to avoid heavy mortalities to fish resulting from the use of explosives. Rasmussen (1967) and McDonald (1973) have shown that there are several precautions that can be taken.

a) The lethal effects of blasting are quickly diminished by distance, a 2.5 pound charge of Geogel is lethal to fish to a distance of 50 feet.

b) The deeper the charges are buried into the substrate, the more the lethal effects are reduced.

c) Major detonations should be a series of successive charges with sufficient delay between firings to allow dissipation of most of the shock wave.

d) Concentrations of fish in areas where explosives are being used can be dispersed by the use of sonic or electrical shock devices.

Operational Phase

Site Preference

From the fisheries view point, *Site 6 is considered to be preferable to Site 7 because:*

a) It is less disruptive of already-existing, high quality stream habitats. The reservoir behind Site 7 would flood all of the highly productive warm water habitat in the Raven River as well as the lower reaches of Stauffer Creek. The latter is occupied by both northern pike and large brown trout.

b) The reservoir behind Site 7 floods several miles of mountain whitefish spawning and nursery habitat in the Red Deer River upstream of the Raven River. In contrast, it does not appear that any significant population of whitefish spawns downstream of the Raven River in the area to be flooded by the dam at Site 6.

c) Winter drawdown at Site 6 will expose a smaller area in both absolute and relative terms (Table 12) than will occur at Site 7 with considerable less effect on invertebrate populations.

d) The volume of water remaining during winter

drawdown is greater behind Site 6 than at Site 7, more than 60% greater at average winter drawdown. This will provide better overwintering conditions for fish and, in particular, reduce the chance of severe winter oxygen deficits.

e) The reservoir at Site 6 will be deeper, with a relatively smaller surface. For this reason, it is more likely to retain the characteristics of a cold water reservoir than that at Site 7. Cold water sports species, particularly the mountain whitefish, would be expected to do better here, in competition with coarse species such as suckers, than in the shallow, warmer, more productive reservoir which would develop behind Site 7.

Pattern of Discharge

Regarding the pattern of discharge, we recommend the following:

a) In comparison with epilimnial release, the summer discharge of waters from the hypolimnion will result in lower water temperatures, increased nutrient loadings and reduced downstream movement of phytoplankton and zooplankton. The total effect will be to provide a stretch of cold water habitat for some distance downstream of the dam. Because there will be both a spillway for epilimnial release and low level discharge ports for hypolimnial release incorporated in the dam structure, there will be considerable flexibility

available for manipulating discharge and the characteristics of the release water. Aquatic Environments Limited's recommendations would be:

- i) that initially *the reservoir be operated during the summer as a natural lake with epilimnial release only*, thereby improving the conditions for the warm water fauna already existing downstream
 - ii) that there be careful monitoring of selected water quality and biological parameters both in the reservoir and downstream (see section on Further Studies below)
 - iii) if the results of the monitoring program indicate its advisability, summer hypolimnial release can be instituted.
- b) *Winter discharges should be maintained at at least historical monthly averages but should not exceed the minimum volumes necessary to provide adequate supplies of high quality water downstream. This will minimize the detrimental effects of winter water level fluctuations in the reservoir. This will not detrimentally affect fish populations downstream but will benefit those inhabiting the reservoir.*
- c) *Changes in discharge volumes should be gradual to*

minimize scouring on the one hand and entrapment on the other. Major changes should take place over a minimum period of 72 hours.

Fish Passage Facilities

Consideration should be given to the provision of fish passage facilities. Fishways or fish ladders, as they are often called, are in world-wide use to pass fish around or over natural and man-made obstructions. In the United States and Canada they are most often used to pass commercially valuable runs of salmon and sea-run trout up coastal drainages to spawning areas. In all cases the fish are large, strong swimmers, and driven by very strong instinctual urges to return to the same drainage where they were spawned to complete their life cycle. All five species of Pacific salmon die after spawning while the Atlantic salmon and sea-run trout often survive to make more than one spawning migration.

These commercial species of salmon have been extensively managed for many years. Counting weirs, aerial surveys, tagging programs, and emergent fry sampling, enable management biologists to keep close tabs on their numbers and reproductive success. Information is readily available whenever it becomes necessary to provide fish passage facilities around a new hydro project or around natural obstructions

into previously uninhabited waters.

The Red Deer River Flow Regulation Project presents an entirely different situation. Little is known of the numbers of fish migrating past these damsites or the adaptability of the species involved in using a fishway to surmount the 90-foot dam.

As previously mentioned, the mountain whitefish is the species most likely to be adversely affected by the construction of a dam. The mountain whitefish is basically a cold water sports fish, with most fish spending the summer upstream of the damsites. In addition, the distribution of fry and data from fall spawning surveys, indicate that most if not all reproduction takes place in the cold water environment above the damsites. There is however, a considerable number of juvenile mountain whitefish that apparently remain downstream of the damsites throughout the year (individuals were taken as far downstream as Morrin) and post-spawning surveys indicate that many spawned-out adult fish move downstream to overwinter. Concentrations of spawned-out adults were found in the vicinity of Innisfail, Penhold, and below the city of Red Deer.

A fishway could solve the problem of providing upstream access to the traditional spawning areas and summer feeding areas for the portion of the mountain whitefish population trapped downstream by the dam closure.

Several types of fishways are in use in Canada and in cases where mountain whitefish are present, have proven to be effective in passing them over dams. Some of these are:

a) A vertical slot fishway on the Bow River successfully passes trout, mountain whitefish and suckers over the 12-foot high Carseland dam.

b) A weir-type fishway on the Yukon River near Whitehorse successfully passes salmon, grayling, whitefish and suckers over a 50-foot high dam (Clay, 1961).

c) Weir-type fishways with submerged orifices in the baffles have a long history of use in the many large dams on the Columbia River and successfully pass many species of fish including whitefish over dams as high as 94 feet (Clay, 1961).

d) Another type of fishway has been recently developed by the Aeroceanics Fishway Corporation. The basic design is an ascending ramp in a spiral form with vertical baffles to impede the water flow. One of these is in place on the Saugeen River at Southampton, Ontario, and another small one has been installed on the Sheep River at Turner Valley, Alberta.

This type of fishway, called the fish escalator, is reported to have several advantages over conventional designs including:

- a) It is inexpensive; prefabrication and fiberglass construction indicate reduced material and installation costs.
- b) Its vertical configuration uses less space.
- c) It is lightweight and easily transported.
- d) Theoretically, there is no limit to the height of the installation. Resting pools can be provided at intervals, one for every 15 feet of rise in elevation is recommended.
- e) Theoretically, it can accommodate all fish species.

Fishway Costs

Fishway costs vary widely depending upon the size and complexity of the installation. Fishways that are added at some time after the construction of the dam are also considerably more expensive than a similar facility constructed along with the dam.

The costs of recent fishway construction in Alberta has ranged between \$4,000 and \$10,000 per foot rise in elevation.

The four-foot high fish escalator at Turner Valley cost \$16,000 for fabrication, transportation and installation. The vertical slot fishway over the 12 foot high Carseland dam cost approximately \$110,000. The estimated cost for a fishway under construction over a 5-foot irrigation dam

in Calgary is about \$50,000. The costs for the Carseland dam and the irrigation dam in Calgary are thought to be considerably inflated due to the fishways being added after the dams were completed (Gerry Thompson, Calgary Regional Fisheries Biologist, personal communication).

It is virtually impossible to compare the costs of fishways constructed on other large dams to what a fishway might cost on the Red Deer River Flow Regulation dam. On large hydroelectric projects many fishways are incorporated into the powerhouse construction as well as the spillways. In addition the fishways are much larger than those that would be needed on the Red Deer River. A large fishway of this type constructed over a 100-foot Columbia River dam cost in excess of 13 million dollars (Clay, 1961).

Fish Culture Facilities

Consideration should be given to the provision of fish culture facilities. While it is possible that reduced suspended sediments and scouring may produce suitable spawning habitat for mountain whitefish and other species immediately below the dam, there are other possibilities which should be considered.

a) The provision of an artificial spawning channel for species such as the mountain whitefish which in the absence of a fishway would be unable to return to their

spawning grounds. Spawning channels with substrate of clean gravel have been constructed adjacent to natural channels to augment natural spawning grounds of salmon in British Columbia (Clay, 1961). A similar channel, placed downstream of the dam on the Red Deer River and supplied with water from the reservoir, could provide adequate spawning area to maintain populations downstream. However, little is known of the spawning requirements of the fish species inhabiting the Red Deer River below the dam and considerable research would be required to determine whether such a project would be feasible.

b) Another possible alternative is a fish hatchery. Such a facility could provide stocks of fish to develop a large sports fishery especially during the initial highly productive phase of the impoundment. On a continuing basis a put and take fishery could be developed, possibly of rainbow trout. A successful fishery of this type has been developed in a cold water reservoir in Montana (Posewitz, 1962).

Trout Stocking

To take advantage of the high initial productivity which will result from the flooding of the reservoir, *AEL recommends that the reservoir be stocked with rainbow trout in the spring of the first year of operation.* It is anticipated that this

would provide a sizeable sports fishery for a period of several years, declining thereafter as the primary productivity of the basin reaches its base level. In order to maximize the benefit of this short-term fishery, there should be an extensive publicity campaign.

Further Studies

If a decision is made to actually construct a dam at one of the two sites, *a number of studies should be initiated*. These include:

1) *Migration Study*. At this time there are not precise quantitative data concerning the actual numbers and patterns of seasonal migration of fish moving upstream and downstream past the damsites. Such data are required to determine whether a fishway is economically and biologically feasible and, if so, to determine the characteristics it must have in order to accommodate the species which will be passing upstream.

Fish work could begin in the spring of 1975 and continue until freeze-up. It would involve the construction and operation of a weir on the Red Deer River in the vicinity of the damsite. Total cost, including construction materials is estimated at approximately \$65,000. To be most effective

this study should be carried out in conjunction with the study of fish passage facilities outlined below.

2) *Fish Passage Facilities*. This study would involve:

- i) a review of available information concerning the design and costs of various types of fish passage facilities;
- ii) an assessment of the swimming performance capabilities of the species most likely to utilize any fish passage facility, and finally the design of a fish passage facility appropriate to the situation on the Red Deer River. The term of this study will be approximately one year. Costs are estimated at approximately \$45,000.

3) *Monitoring Studies*. A dam on the Red Deer River would provide an excellent opportunity to monitor quantitatively the effects of dam construction on aquatic habitats in general and fish populations in particular. Such data are not now available for east slope reservoirs in Alberta.

AEL recommends that a program be established to monitor selected physical, chemical and biological parameters during both the construction and operational phases of the project. This study should begin immediately so that preliminary

baseline data are available for each of the selected parameters prior to any dam-related disturbance in the area. Such a program should continue over a period of years until conditions in the reservoir appear to have stabilized. The costs for the first year are estimated at approximately \$50,000. Costs in subsequent years should be significantly reduced.

4) *Management Studies.* Data obtained in the aforementioned study would provide a well documented basis for the rational management of fisheries both in the reservoir and downstream. The study would result in recommendations concerning such things as stocking rates for hatchery fish, catch limits, closed seasons, closed areas; fisheries enhancement measures such as habitat improvement, fish culture facilities, coarse fish removal programs, etc. Management studies should be initiated as soon as a decision is made to begin the project. It is anticipated that the costs would be about \$30,000 for the first year when the initial fisheries management program is being designed and declining as programs become self-sustaining.

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APPENDIX A. Summary of field water quality data obtained during the course of fisheries investigations for Red Deer River Damsite Studies, 1974. Sampling locations in order from headwaters downstream, samples from individual sampling locations ordered by date. All values are for ambient temperature.

- TABLE
1. Mainstem Red Deer River, Region I
 2. Mainstem Red Deer River, Region II
 3. Raven River System

APPENDIX TABLE A-1. Summary of Water Quality data, mainstem
Red Deer River, Region I, 1974.

Location	Date	Temp. °C	O ₂ ppm	Cond. µmho/cm	pH units
Big Horn Ck.Campground	Oct. 1	8	10	220	7.6
Pool above Mtn.Aire Lodge	May 2	3	11	-	8.0
2mi.D.S.from Mtn.Aire Lodge	July 31	11	11	200	7.75
1st.Rapid 6mi.above Sundre	May 2	4	10	-	8.0
1st.Rapid 6mi.above Sundre	June 11	12.5	12	280	8.0
10mi. above Sundre	Oct. 1	4	11	180	7.8
5 mi. above Sundre	June 14	14	12	240	7.9
2 mi. above Sundre	June 13	13.5	12	205	7.8
2 mi. above Sundre	June 14	14	12	240	7.9
Sundre Campground	May 3	6.5	11	-	7.9
Sundre Campground	Oct. 3	6	11	185	7.0
Sundre Boat Launch Site	Aug. 13	11,	-	225	7.7
Sundre Campground	June 11	15	12	275	8.0
5 mi.D.S. from Sundre	July 24	17	10	260	8.0
Water pump site N.of Sundre	Oct. 10	8	-	-	-
South Channel at mouth of James River	June 5	11	11	195	7.8
Garrington Corner	Apr. 26	7	11	161	8.6
Garrington Corner	Oct. 10	7	-	-	-
Bowden Bridge	June 18	17	10	225	7.9
Bowden Bridge	June 30	15	9	240	7.9

APPENDIX TABLE A-1 continued.

Location	Date	Temp. °C	O ₂ ppm	Cond. µmho/cm	pH units
Bowden Bridge	July 11	14	10	275	8.5
Bowden Bridge	July 30	18.5	9	300	7.95
Bowden Bridge	Aug. 9	17	10	260	8.0
Bowden Bridge	Aug. 16	17	10	315	7.9
Bowden Bridge	Sept. 12	11	10	245	7.8
Bowden Bridge	Oct. 9	9	-	-	-
5 mi. above Raven	May 22	11	11	-	7.6
Upper Gillnet Site	May 22	10	11	-	7.8
Upper Gillnet Site	May 24	12	11	-	8.0
Upper Gillnet Site	June 7	9	11	160	7.8
Upper Gillnet Site	July 17	17	10	260	7.9
Upper Gillnet Site	July 18	15	9	245	7.9
100 m above Raven	July 25	17.5	10	290	8.0
100 m above Raven	Aug. 27	15	10	260	8.0
1/4 mi. above Raven	Sept. 30	12	10	260	7.8
Lower Gillnet Site	May 21	12	11	-	8.0
Lower Gillnet Site	May 22	10	11	-	7.8
Lower Gillnet Site	June 7	9	11	160	7.8
1/2 mi. below Raven	June 17	18	10	251	7.8
1/2 mi. below Raven	July 18	17	10	295	7.9
200 m. below Raven	July 25	18	11	300	8.1
100 yds. below Raven	Aug. 27	15	10	260	8.0
100 m below Raven	Sept. 30	12	-	290	7.8

APPENDIX TABLE A-1 continued.

Location	Date	Temp. °C	O ₂ ppm	Cond. μmho/cm	pH units
Campground S.of Dickson	Aug. 16	±16	11	310	7.9
Campground S.of Dickson	Sept.12	11	11	240	7.8
Damsite No.6	May 6	11	10	-	7.8
Damsite No.6	June 30	17	9	315	7.1

APPENDIX TABLE A-2. Summary of Water Quality data, mainstem Red Deer River, Region II, 1974.

Location	Date	Temp. °C	O ₂ ppm	Cond. µmho/cm	pH units
Below Innisfail Bridge	Apr. 28	8	10	160	8.5
Innisfail Bridge	May 3	8	10	-	7.95
Innisfail Bridge	May 7	13	10	230	7.8
Innisfail Bridge	July 11	17	9	275	8.0
Innisfail Bridge	July 30	19	10	300	7.9
Innisfail Bridge	Aug. 9	18	11	290	7.2
Innisfail Bridge	Aug. 16	18	10	255	7.9
Innisfail Bridge	Aug. 20	15	10	260	7.9
Innisfail Bridge	Oct. 9	8	-	-	-
7 mi. above Penhold	May 7	13	10	230	7.8
Below Red Deer	May 14	9	10	223	8.0
6mi. below Red Deer	Aug. 21	15	11	255	8.1
Joffre Bridge	May 14	9	10	225	8.0
Mouth of Tail Creek	May 16	12	10	270	7.9
Vicinity of Tail Creek	Aug. 22	17	12	310	8.0
Tolman Bridge	May 16	12	10	260	8.0
Morrin Bridge	May 16	10	-10	250	8.1
Morrin Bridge	Aug. 23	19	11	310	8.0

APPENDIX TABLE A-3. Summary of Water Quality data from detailed study area, Raven River System, 1974.

Location	Date	Temp. °C	O ₂ ppm	Cond. µmho/cm	pH units
Raven R. @lower Bridge	Apr. 26	8	10	220	8.5
Stauffer Ck. 1st. Bridge above Raven	Apr. 28	8	9-10	200	8.6
Stauffer Ck. So. Fork Sundre Rd.	May 1	8	12	-	7.8
Stauffer Ck. No. Fork	May 1	7	14	-	8
Raven R. 3/4 mi. So. of Caroline	May 1	6	10-11	-	7.8
Raven R. confluence with Red Deer	May 21	12	9	-	7.7
Raven R. @Mouth	May 22	11	11	-	7.6
Raven R. 100 m up from Mouth	May 24	13	10	-	7.8
Raven R. 1/2 mi. Above Lower Bridge	June 7	11	10	300	7.9
Raven R. @Campground mouth Stauffer Ck.	June 17	18	9	390	8.0
Raven R. 1/2 mi. from Caroline	June 17	19	9	425	8.2
Stauffer Ck. near Head- waters	June 17	15	10	400	7.6
Stauffer Ck. near Mouth	June 15	22	10	450	7.9
Stauffer Ck. 10 mi. E. of Caroline	June 18	17	11	500	8.2
Raven R. near Mouth	June 30	18	10	420	7.0

APPENDIX TABLE A-3. continued.

Location	Date	Temp. °C	O ₂ ppm	Cond. μmho/cm	pH. units
Raven R. @Lower Bridge	July 11	17	8	350	8.1
Raven R. 1/2 mi. above Lower Bridge	July 16	19	10	420	8.1
Raven R. 1/2 mi. above Lower Bridge	July 18	24	9	410	8.0
Raven R. @Mouth	July 24	21	9	410	8.1
Raven R. Lower Bridge	July 30	18	9	380	8.0
Raven R. @Lower Bridge	Aug. 9	18	8-9	360	8.0
Raven R. @Lower Bridge	Aug. 16	20	11	375	7.9
Raven R. @Lower Bridge	Aug. 27	15	11	350	7.8
Raven R. @Lower Bridge	Sept.12	7	12-13	300	7.0
Raven R. Near Mouth	Sept.20	11	11	350	7.8

APPENDIX B. Summary of catch data showing location, date, and method of capture for all species taken in Regions I and II.

Species codes used in this Appendix are based on the approved common name of the species and are listed in the text in Table 2.

SUMMARY OF CATCH DATA
COLD WATER SPORTS SPECIES
REGION I

Location	Date	Number of each species captured					Effort	Total
		MTWF	BNTR	BKTR	DOLL	RBTR		
		<u>SEINING</u>						
Raven R., lower bridge Stauffer Cr. (N fork) below culvert	26/04/74	9					15 m	9
S. Raven R., 3/4 mi S of Caroline	01/05/74		2				50 m	2
Red Deer R., 6 mi above Sundre	01/05/74	29					50 m	29
Red Deer R., Sundre campground	02/05/74	24					50 m	24
Fallen Timber Cr., below Bergen	03/05/74	4					50 m	4
Fallen Timber Cr., Provincial campground	03/05/74	1					30 m	1
James R., N of Sundre	03/05/74		1				30 m	1
Red Deer R., damsite #6	03/05/74	3					30 m	3
Red Deer R., 1/2 mi below Raven R.	06/06/74	3					50 m	3
Red Deer R., 1 mi below James R.	21/05/74	7					30 m	7
Red Deer R., Sundre	05/06/74	5					20 m	5
Fallen Timber Cr., Bergen	11/06/74	4					40 m	4
Fallen Timber Cr., end of road.	25/06/74	3					40 m	3
Red Deer R., Garrington Corner side channel	26/06/74	2		1			30 m	3
Red Deer R., main channel, Garrington Corner	26/04/74	30					40 m	30
Red Deer R., 6 mi above Sundre	26/04/74	24					40 m	24
Red Deer R., 4 mi above Sundre	13/08/74	1		2			100 m	3
Red Deer R., Sundre	13/08/74	3					40 m	3
Red Deer R., 5 mi below Sundre	13/08/74	7		3			50 m	10
James R., 1 mi from mouth	14/08/74	6					50 m	6
Red Deer R., @ Dickson campground	14/08/74	3					50 m	3
	16/08/74	6					50 m	6

(continued)

SUMMARY OF CATCH DATA
COLD WATER SPORTS SPECIES (CONTINUED)

REGION I

Location	Date	Number of each species captured					Effort	Total
		SEINING (CONTINUED)						
		MTWF	BNTR	BKTR	DOLL	RBTR		
Red Deer R., @ Dickson campground	09/10/74	13					150 m	13
Red Deer R., Garrington Corner	09/10/74	31					100 m	31
Red Deer R., Garrington Corner	10/10/74	52					100 m	52
James R., at James R. bridge	10/10/74	17					40 m	17
Red Deer R., 5 mi below Sundre	10/10/74	30					30 m	30
Brown Cr. (Williams Cr.)	02/05/74	5					50 m	5
Red Deer R., 6 mi above Mountain Air Lodge	31/07/74	3					10-15 m	3
Red Deer R., 2 mi below Mountain Air Lodge	31/07/74	7					100 m	7
Red Deer R., 1/2 mi below Yara Cr.	01/08/74	1				1	100 m	2
Red Deer R., Dickson	17/10/74	1					100 m	1
Red Deer R., 2 mi above Sundre	16/10/74	7					150 m	7
Red Deer R., Garrington Corner	16/10/74	11				1	150 m	12
Red Deer R., Garrington Corner	18/10/74	5					75 m	5
Red Deer R., Garrington bridge	10/10/74	15					40 m	15
Red Deer R., Garrington bridge	14/08/74	5					50 m	5
Red Deer R., 3 mi below Garrington bridge	14/08/74							
Red Deer R., Garrington bridge	09/10/74	16					50 m	16
Red Deer R., Garrington bridge	26/04/74	11					30 m	11
Red Deer R., above Garrington bridge	05/06/74	1					30 m	1
James R. mouth								
TOTALS SEINING		409	1	10				420

SUMMARY OF CATCH DATA
COLD WATER SPORTS SPECIES (CONTINUED)

REGION I

Location	Date	Number of each species captured					Effort	Total	
		MTWF	BNTR	BKTR	DOLL	RBTR			
<u>GILLNETTING</u>									
Raven R. mouth	21/05/74	1					2 hrs	1	
Red Deer R., 1/4 mi above									
Raven R.	22/05/74	3		3			18 hrs	6	
Raven R. mouth	22/05/74	5					20 hrs	5	
Red Deer R., 1 mi above Raven R.	24/05/74	1					20 hrs	1	
Red Deer R., 1/4 mi above									
Raven R.	07/06/74			1			20 hrs	1	
Red Deer R., 1/2 mi above									
Raven R.	07/06/74			1			19 hrs	1	
Raven R., 1/2 mi above lower									
bridge	07/06/74		2				22 hrs	2	
Red Deer R., 5 mi above Sundre	14/06/74		1	2	3		20 hrs	6	
Red Deer R., 5 mi below Sundre	24/07/74						1 hr	1	
Raven R., mouth	28/08/74	1					18 hrs	1	
Red Deer R., 2 mi above Sundre	11/10/74	1					1 hr	1	
Red Deer R., Garrington Corner	17/10/74	6					2 hrs	6	
Red Deer R., 5 mi below Sundre	18/10/74	3					18 hrs	3	
		5						5	
TOTALS GILLNETTING		27	3	7	3			40	

SUMMARY OF CATCH DATA
COLD WATER SPORTS SPECIES (CONTINUED)

REGION I

Location	Date	Number of each species captured					Effort	Total
		MTWF	BNTR	BKTR	DOLL	RBTR		
<u>ELECTROFISHING</u>								
Sundre Cr., S of Sundre	11/06/74			4	2		234 sec	6
Stauffer Cr., near headwaters	17/06/74			30			245 sec	30
Stauffer Cr., near mouth	18/06/74		2				465 sec	2
Stauffer Cr., 10 mi E of Caroline	18/06/74		11	2			289 sec	13
TOTALS ELECTROFISHING								
			13	36	2			51
<u>ANGLING</u>								
Fallen Timber Cr., Provincial campground	03/05/74		1				1 hr	1
Fallen Timber Cr., above campground	05/05/74		1				2 hr	1
Red Deer R., muskeg backwater 5 mi above Raven R.	22/05/74				1		45 min	1
TOTALS ANGLING								
			2		1			3

SUMMARY OF CATCH DATA
WARM WATER SPORTS SPECIES

REGION I

Location	Date	Number of each species captured				Effort	Total
		PIKE	MOON	GOLD WALL	SAUG BURB		
<u>GILLNETTING</u>							
Raven R. mouth	21/05/74			2		2 hrs	2
Red Deer R., 1/2 mi below Raven R.							
Raven R. mouth	22/05/74				2	18 hrs	2
Raven R., 100 m up from mouth	22/05/74	1		2		20 hrs	3
Raven R., 1/2 mi above lower bridge	24/05/74	4				20 hrs	4
Red Deer R., 1/2 mi above Raven R.	07/06/74	1		4		22 hrs	5
Raven R., 1/2 mi above lower bridge	17/07/74		1			17 hrs	1
Red Deer R., 1/2 mi above Raven R.	18/07/74		7	1		18 hrs	8
Raven R. mouth	18/07/74				1	18 hrs	1
Raven R., 1/4 mi up from lower bridge	24/07/74	1	2	1	11	20 hrs	15
Raven R. above lower bridge	28/08/74	1				4 hrs	1
Red Deer R., 1.5 mi above Raven R.	29/08/74		7				7
Red Deer R., 100 m below Raven R.	29/08/74				1	3 hrs	1
Raven R., 1/2 mi above lower bridge	20/09/74			1		2 hrs	1
Raven R. mouth	16,17/07/74			14	2	32 hrs	16
Raven R. mouth	28/08/74	3	2		3	18 hrs	8
Raven R. mouth	29/08/74		1			18 hrs	1
TOTALS GILLNETTING		11	12	23	28		76

SUMMARY OF CATCH DATA
WARM WATER SPORTS SPECIES (CONTINUED)
REGION I

Location	Date	Number of each species captured			Effort	Total
		PIKE	MOON	GOLD WALL	SAUG	BURB
Stauffer Cr. near mouth	10/06/74	ELECTROFISHING			465 sec	1
		<u>1</u>				
TOTAL ELECTROFISHING		1				1
Raven R. mouth	14/07/74	ANGLING			4 hrs	4
		<u>1</u>				
TOTAL ANGLING		1				4
		<u>3</u>				
		3				

SUMMARY OF CATCH DATA

IMPORTANT NON-GAME SPECIES

REGION I

Location	Date	Number of each species captured					Effort	Total
		LNDC	LKCB	LNSK	WTSK	MTSK		
		SEINING						
Raven R., lower bridge	26/04/74	243					15 m	243
Raven R., riffle below third bridge	26/04/74	12		24	12		40 m	48
Stauffer Cr., below S fork Sundre R.	01/05/74		4		1		20 m	5
S. Raven R., 3/4 mi S of Caroline	01/05/74	4		12	2		50 m	18
Red Deer R., Sundre campground	03/05/74	11		1	2		50 m	14
Fallen Timber Cr., below Bergen	03/05/74	17			2		30 m	19
James R., N of Sundre	03/05/74	7	1		1	2	30 m	13
Red Deer R., damsite #6	06/05/74	71	1	10		38	50 m	131
Red Deer R., 1/2 mi below Raven R.	21/05/74	28	9	30		4	30 m	71
Red Deer R., 1 mi below James R.	05/06/74	7			3		20 m	10
Red Deer R., Sundre	11/06/74	1					40 m	1
Fallen Timber Cr., end of road	26/06/74			1		1	30 m	2
Fallen Timber Cr., campground	26/06/74			2			80 m	2
Red Deer R., Garrington Corner	26/04/74	36				37	100 m	73
Red Deer R., Garrington Corner	26/04/74	3		8		4	40 m	15
James R. mouth	05/06/74					1	30 m	1
Brown Cr. above bridge		75					100 m	75
Red Deer R., 3 mi below Brown Cr	01/08/74				2		50 m	2
Red Deer R., 6 mi above Sundre	13/08/74	2		1			100 m	3
Red Deer R., Sundre	13/08/74	13					50 m	13
Bearberry Cr., Sundre bridge	13/08/74	12			1	2	20 m	15
Red Deer R., 5 mi below Sundre	14/08/74	3			1		50 m	4
James R., bridge N of Sundre	14/08/74	1					50 m	1
Fallen Timber Cr., 10 mi above Bergen	16/08/74	100			1		200 m	151

(continued)

SUMMARY OF CATCH DATA

IMPORTANT NON-GAME SPECIES (CONTINUED)

REGION I

Location	Date	Number of each species captured					Effort	Total
		SEINING (CONTINUED)						
		LNDC	LKCB	LNSK	WTSK	MTSK		
Red Deer R., Garrington Corner	10/10/74	100+					100 m	200+
Red Deer R., 5 mi below Sundre	10/10/74	10					30 m	35
Red Deer R., 2 mi above Sundre	16/10/74		25				150 m	3
Red Deer R., Garrington Corner	16/10/74			3			150 m	5
Red Deer R., Garrington bridge	07/10/74			5			100 m	6
Red Deer R., Dickson campground	09/10/74	50		6			150 m	50
Red Deer R., Garrington bridge	14/08/74	4					50 m	4
Red Deer R., 3 mi below Garrington bridge	14/08/74	6				2	50 m	8
Red Deer R., above Garrington bridge	26/04/74	96				33	30 m	129
James R., mouth	05/06/74	45	1	1	1	55	30 m	104
TOTAL SEINING		957	16	129	129	174	70	1474

GILLNETTING

Raven R., mouth	21/05/74	1					2 hrs	1
Red Deer R., 1/4 mi below Raven R	22/05/74	4			3		18 hrs	7
Raven R., mouth	22/05/74				6		20 hrs	6
Red Deer R., 1 mi above Raven R.	24/05/74				6		20 hrs	6
Raven R., 100 m up from mouth	24/05/74	1			1		20 hrs	2
Red Deer R., 1/2 mi above Raven R	07/06/74	1					19 hrs	1
James R., mouth	05/06/74					1	23 hrs	1
Red Deer R., 1/2 mi above Raven R	07/06/74	2					20 hrs	2
Raven R., 1/2 mi below lower bridge	07/06/74							
Red Deer R., 2 mi above Sundre	13/06/74	5			11		22 hrs	16
Red Deer R., 1/2 mi above Raven R	17/07/74	8			1		20 hrs	9
		1			2		17 hrs	3

(continued)

SUMMARY OF CATCH DATA
IMPORTANT NON-GAME SPECIES (CONTINUED)

REGION I

Location	Date	Number of each species captured					Effort	Total
		LNSK	LKCB	WTSK	MTSK	TRPH		
GILLNETTING (CONTINUED)								
Raven R., 1/2 mi above lower bridge	18/07/74	7					18 hrs	7
Raven R., mouth	24/07/74	12					20 hrs	12
Raven R., 1/4 mi up from lower bridge	28/08/74	3					4 hrs	3
Red Deer R., 1.5 mi above Raven R	29/08/74	4					3 hrs	4
Red Deer R., 100 m below Raven R.	20/09/74	2					2 hrs	2
Red Deer R., 1/2 mi above Raven R	07/06/74	1					19 hrs	1
Raven R., 1/2 mi above lower bridge	16, 17/07/74	1					32 hrs	15
Raven R., mouth	28/08/74	6					18 hrs	13
Red Deer R., 5 mi below Sundre	18/10/74	2					18 hrs	3
TOTAL GILLNETTING								
		24	80	1				113
ELECTROFISHING								
Eagle Cr., culvert	26/04/74	5				21	276 sec	26
Raven R., provincial campground	17/06/74	3				1	311 sec	6
Raven R., 3/4 mi S of Caroline	17/06/74	2					541 sec	2
Stauffer Cr., near mouth	18/06/74	1				1	465 sec	2
Stauffer Cr., 10 mi E of Caroline	18/06/74							
James R., 20 mi W of bridge	19/06/74	1				1	289 sec	4
Bearberry Cr., W of Sundre	19/06/74	3	1			4	343 sec	5
Unnamed Cr. near Garrington bridge	19/06/74	1					290 sec	9
		1	1	13			238 sec	15
TOTAL ELECTROFISHING								
		8	7	7	19	26		69

SUMMARY OF CATCH DATA
IMPORTANT NON-GAME SPECIES (CONTINUED)

REGION I

Location	Date	Number of each species captured					Effort	Total
		LNDC	LKCB	LNSK	WTSK	MTSK TRPH		
Raven R., mouth	14/07/74			4			4 hrs	4
TOTAL ANGLING				4				4

SUMMARY OF CATCH DATA
MINOR NON-GAME SPECIES

REGION I

Location	Date	Number of each species captured						Effort	Total	
		PLDC	FSDC	RUSH	SRSK	BKST	SLSC			SPSC
<u>SEINING</u>										
Raven R., lower bridge	26/04/74						4	15 m	4	
Raven R., riffle below third bridge	26/04/74			2			6	40 m	8	
Stauffer Cr., below S fork Sundre Road	01/05/74	1				7		20 m	8	
S. Raven R., 3/4 mi S of Caroline	01/05/74						2	50 m	2	
James R., bridge N of Sundre	14/08/74						1	50 m	1	
Fallen Timber Cr., Bergen	03/05/74					1		30 m	1	
TOTAL SEINING		1		2		8	13		24	
<u>GILLNETTING</u>										
Raven R., mouth	28/08/74				1			18 hrs	1	
Red Deer R., 5 mi below Sundre	18/10/74						1	18 hrs	1	
TOTAL GILLNETTING					1		1		2	
<u>ELECTROFISHING</u>										
Eagle Cr. culvert	26/04/74					7		276 sec	8	
Raven R., provincial campground	17/06/74						1	311 sec	1	
Raven R., 3/4 mi S of Caroline	17/06/74						1	541 sec	1	
Unnamed Cr., near Garrington bridge	19/06/74							238 sec	2	
TOTAL ELECTROFISHING						7	3		12	

SUMMARY OF CATCH DATA
COLD WATER SPORTS SPECIES
REGION II

Location	Date	Number of each species captured				Effort	Total
		MTWF	BNTR	BKTR	DOLL RBTR		
		<u>SEINING</u>					
Red Deer R., Tail Creek	16/05/74	2				50 m	2
Red Deer R., Innisfail bridge	07/05/74	3				30 m	3
Red Deer R., 2 mi below Innisfail bridge	20/08/74	4				100 m	4
Red Deer R., Innisfail bridge	09/10/74	1				150 m	1
Red Deer R., 2 mi below Innisfail bridge	20/08/74	9				100 m	9
Red Deer R., Joffre bridge	14/05/74	10				60 m	10
Red Deer R., Morrin bridge	16/05/74	1				30 m	1
TOTAL SEINING		30					30

SUMMARY OF CATCH DATA
WARM WATER SPORTS SPECIES

REGION II

Location	Date	Number of each species captured					Effort	Total
		PIKE	MOON	GOLD WALL	SAUG	BURB		
<u>SEINING</u>								
Red Deer R., Joffre bridge	14/05/74		1				60 m	1
Red Deer R., Tail Creek	16/05/74	1	6				50 m	7
Red Deer R., Tail Creek	22/08/74				1		100 m	1
Little Red Deer R., Red Lodge Park	26/04/74	2						2
TOTAL SEINING		3	7		1			11
<u>GILLNETTING</u>								
Red Deer R., Tail Creek	22/08/74		2				4 hrs	2
Red Deer R., 6 mi below Red Deer	21/08/74		2		1	1	2 hrs	5
Medicine River, mouth	23/07/74		6		1		2 hrs	7
TOTAL GILLNETTING			6	4	2	1		14
<u>ANGLING</u>								
Medicine R., mouth	23/07/74		4				2 hrs	5
TOTAL ANGLING			1					5

SUMMARY OF CATCH DATA
IMPORTANT NON-GAME SPECIES

REGION II

Location	Date	Number of each species captured					Effort	Total
		LNDC	LKCB	LNK	WTSK	MTSK		
<u>SEINING</u>								
Little Red Deer R., Red Park Lodge	26/04/74	178	1	6			10 m	189
Little Red Deer R., HWY 27 bridge	05/06/74	1000+	250+		250+	4	10 m	1750+
Dog Pound Cr., HWY 27 bridge	03/05/74	33	18		1		20 m	52
Little Red Deer R. HWY 27 bridge	03/05/74	45	1		4	5	50 m	74
Red Deer R., below HWY 27 bridge	03/05/74	20	1		3	1	10 m	27
Medicine R., 2 mi from mouth	06/05/74	10	1	1	2		50 m	14
Red Deer R., 7 mi above Penhold	07/05/74	45	4	17		10	50 m	76
Red Deer R., HWY 54 bridge	07/05/74	2		1			30 m	3
Little Red Deer R., at HWY 27	25/06/74				7		60 m	7
Little Red Deer R., at HWY 27	27/06/74				8	1		9
Little Red Deer R., 20 mi S of Sundre								
Red Deer R., Innisfail bridge	25/06/74				8		50 m	8
Red Deer R., Joffre bridge	09/10/74	15				3	150 m	18
Red Deer R., Tail Creek	14/05/74	100	50	26	1	15	60 m	192
Red Deer R., Tolman bridge	16/05/74	33	20		2		50 m	55
Red Deer R., Morrin bridge	16/05/74		7				30 m	7
Red Deer R., Tail Creek	16/05/74	100+	100+		2		30 m	202+
Little Red Deer R., HWY 27 bridge	22/08/74	1000+			1000+		100 m	2000+
Little Red Deer R., HWY 27 bridge	11/06/74	1	4		1	2	30 m	8
Red Deer R., Innisfail bridge	13/08/74	10	1		130		100 m	141
Red Deer R., Innisfail bridge	14/08/74	5	70		1	1	30 m	77
Red Deer R., 2 mi below Innisfail bridge	20/08/74	1000+			1000+	1000+		3000+
TOTAL SEINING		3597+	528+	51	2420+	7		7909+

SUMMARY OF CATCH DATA
IMPORTANT NON-GAME SPECIES

REGION II

Location	Date	Number of each species captured					Effort	Total
		LNDC	LKCB	LNSK	WTSK	TRPH		
<u>GILLNETTING</u>								
Red Deer R., 6 mi below Red Deer	21/08/74			5	2		2 hrs	7
Red Deer R., 10 mi below Red Deer	21/08/74				1		3 hrs	1
Red Deer R., 2 mi below Innisfail bridge	20/08/74			1			4 hrs	1
TOTAL GILLNETTING								
				6	3			9
<u>ELECTROFISHING</u>								
Dogpound Cr., HWY 27 bridge	11/06/74						352 sec	9
TOTAL ELECTROFISHING								
								9

SUMMARY OF CATCH DATA
MINOR NON-GAME SPECIES

REGION II

Location	Date	Number of each species captured						Effort	Total	
		PLDC	FSDC	RUSH	SRSK	BKST	SLSC			SPSC
<u>SEINING</u>										
Red Deer R., below HWY 54 bridge	03/05/74				1				10 m	1
Dickson Cr., below road to damsite #6										
Red Deer R., Innisfail bridge	06/05/74				1				30 m	1
Red Deer R., Tail Creek	14/08/74					4			35 m	4
Red Deer R., Tolman bridge	16/05/74			3	50		1		50 m	54
Red Deer R., Morrin bridge	16/05/74			3	50				30 m	53
	16/05/74			6	98				30 m	104
TOTAL SEINING										
		12	198		3	4				217
<u>GILLNETTING</u>										
Red Deer R., Tail Creek	22/08/74			6					4 hrs	6
Red Deer R., 6 mi below Red Deer	21/08/74			4					2 hrs	4
TOTAL GILLNETTING										
				10						10

